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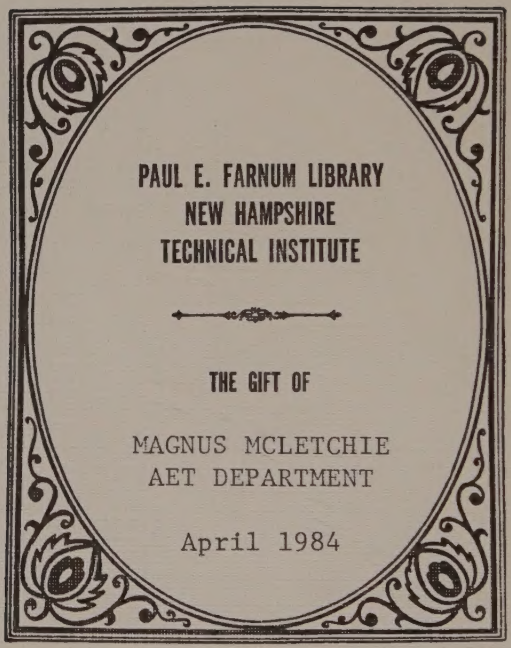

Charles D. Brown

TOPOGRAPHICAL DRAWING

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TOPOGRAPHICAL DRAWING

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PREFACE

There are usually two distinct operations in topographical survey work. The first is that of taking the data in the field, and the second is that of making the final record of this data in the form of a plat or map. In certain forms of topographical sketching and in plane-table work, the field sheet in itself may be the final record of the data. Usually, however, the final record is in the form of a finished map drawn according to appropriate standards of topographical drawing.

Many books have been published describing the field methods of instrumental surveying. Scant attention has been given, however, to the subject of topographical drawing, notwithstanding its importance in the final value of the survey work.

Until recently, no standards of any kind in topographical drawing have been established, and every topographer either worked out his own system or conformed to the practice of the particular office in which he was working.

In 1912, the United States Geographic Board adopted standard conventional signs for the use of all map-making departments of the government. These have been published in pamphlet form as War Department Document No. 418, which can be procured from the U. S. Geological Survey Office, Washington, D. C.

This pamphlet serves to establish standard forms for the various conventional signs, but it leaves untouched the almost equally important subject of standards of practice which will combine good execution with economy of draughting time. The attempt is made in this text to point the way to a satisfactory standard of practice.

Proficiency in topographical drawing requires:

1. Study of the forms and practice in the execution of the individual conventional signs;

2. Study of the forms and practice in the execution of the conventional alphabets used in lettering on topographical maps; and

3. Practice in the execution of conventional signs and lettering in combination (map drawing).

This text is designed as a basis for a course of instruction and practice in topographical drawing. The first six chapters are intended largely for reference, and it will be sufficient for the student to read them carefully. In Chapter VI is laid down a scheme of practice based upon Chapters VII, VIII, IX, X, and XI. The illustrative figures of these five chapters have been prepared with a view to their usefulness in such practice.

When proficiency has been attained in lettering and in the execution of the individual conventional signs, practice in map drawing may be undertaken. This subject is covered in Chapter XII, and a four-color plate is there given as a model for such practice.

The author desires to acknowledge his indebtedness to Captain Oscar Westover, Assistant Professor of Drawing, and to Lieutenant C. S. Floyd, Instructor in Drawing, U.S.M.A., for assistance in the preparation of the plates for this text.

West Point, New York,
June, 1917.

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AUTHORIZED ABBREVIATIONS

A.	Arroyo.
abut.	Abutment.
Ar.	Arch.
b.	Brick.
B.S.	Blacksmith Shop.
bot.	Bottom.
Br.	Branch.
br.	Bridge.
C.	Cape.
cem.	Cemetery.
con.	Concrete.
cov.	Covered.
Cr.	Creek.
cul.	Culvert.
D.S.	Drug Store.
E.	East.
Est.	Estuary.
f.	Fordable.
Ft.	Fort.
G.S.	General Store.
gir.	Girder.
G.M.	Grist Mill.
i.	Iron.
I.	Island.
Jc.	Junction.
k.p.	King Post.
L.	Lake.
Lat.	Latitude.
Ldg.	Landing.
L.S.S.	Life Saving Station.
L.H.	Light House.
Long.	Longitude.
Mt.	Mountain.
Mts.	Mountains.
N.	North.
n.f.	Not Fordable.
p.	Pier.
pk.	Plank.
P.O.	Post Office.
Pt.	Point.
q.p.	Queen-post.
R.	River.
R.H.	Roundhouse.
R.R.	Railroad.
S.	South.
s.	Steel.
S.H.	School House.
S.M.	Saw Mill.
Sta.	Station.
st.	Stone.
str.	Stream.
T.G.	Tool Gate.
Tres.	Trestle.
tr.	Truss.
W.T.	Water Tank.
W.W.	Water Works.
W.	West.
w.	Wood.

TOPOGRAPHICAL DRAWING

CHAPTER I

Introductory

Topographical drawing is the art of recording topographical data in the form of a map. One extreme of this work is the draughting in connection with the field notes in instrumental surveying. These notes and accompanying sketches may be made without great attention to finished appearance, but even here there is no room for carelessness. Much of the value of the field work depends upon the accuracy and clearness of the field notes and sketches. These notes and sketches are usually made in pencil for facility in making corrections. A fountain pen may be used, in which case the lines should be fine in order to avoid blotting.

The other extreme of topographical drawing is the *office record map.* In accurate instrumental surveys, the results should be recorded in a map in which the standard of draughting is as high as is the standard of the instrumental work in the field. Herein is a field for the exercise of all the refinements of the topographical draughtsman's art. The office record map should be executed in four colors,—blue for the water features; brown for contours; green for vegetation symbols; and black for lettering, for roads, railroads, and boundaries, and for other artificial constructions.

A map may be traced for reproduction by blueprinting, and this work requires of the draughtsman a knowledge of the minor modifications in method required for clearness in topographical drawing in a single color. The topographical draughtsman must also be familiar with field draughting methods, because much of his work consists in transcribing the data from the field sheets to the finished map. In fact, the topographical draughtsman should

also be a topographer, for only in that way can he be prepared to interpret the data of the field work intelligently.

Topographical drawing is a combination of mechanical and free-hand drawing, and includes a large amount of lettering as well. Many of the topographical symbols are executed free-hand, by methods closely akin to those of free-hand lettering. Proficiency is attained by careful attention to the details of execution, and by painstaking practice. As in all other classes of drawing, natural aptitude is a valuable asset, but a good measure of proficiency is within the reach of all who are willing to take the trouble to learn.

Proficiency in topographical drawing requires a knowledge of the use of the ordinary drawing instruments and methods, particularly of the right-line pen in conjunction with the T-square, triangles, and irregular curve. The topographical draughtsman will need to acquire facility in the use of a number of additional instruments, such as the railroad pen, the curve or contour pen, the pantograph, and certain other instruments, all of which will be described in the chapter on the use of instruments.

Classification of Maps.

Maps may be grouped in four general classes:

1. *Geographic Maps*, on scales of from one inch to about fifteen miles (1:1,000,000) to one inch to one mile (1:63,360);
2. *General Topographic Maps*, on scales from one inch to one mile (1:63,360) to six inches to one mile (1:10,560);
3. *Cadastral Maps*, on scales from six inches to one mile (1:10,560) to one inch to two hundred feet (1:2,400),
4. *Engineering Maps*, prepared for the planning and execution of engineering works, such as railroads, roads, canals, etc., together with accurate or approximate estimates or computations of cost. Such maps are made on scales varying from one inch to two hundred feet (1:2,400) to as large as one inch to fifty feet (1:600), depending upon the importance of the work in contemplation.

Scale of Maps.

Mechanical and architectural drawings are executed on scales varying from full size detail drawings (1:1) to general drawings

on a scale of $\frac{3}{32}$ of an inch to the foot (1:128). The figures in parenthesis represent the ratio of the distance on the drawing to the actual distance on the object represented. In topographical maps, this ratio is written as a fraction and is called the *representative fraction.*

Maps are drawn on various scales, depending upon the uses for which they are intended and upon the character and extent of the area to be represented. Even the largest scale maps are, however, drawn on a scale much smaller than the smallest used in general drawings.

The governing consideration in the determination of the scale of a map is the amount of detail required to be shown, and this in turn is determined by the purpose for which the map is made. The limitations of various scales can be most vividly impressed upon the mind by considering the minimum dimensions of an object that may be drawn to scale. Without serious error, one-fiftieth of an inch may be taken as the inferior limit of absolute dimension to which a draughtsman can work, and also as the inferior limit of the size of a symbol or other dimension that would be seen in reading a map. On a scale of 1:1,000,000, this distance represents 20,000 inches, or almost one-third of a mile; on a scale of one inch to one mile (1:63,360), it represents 106 feet; on a scale of six inches to one mile (1:10,560), 18 feet; and on a scale of one inch to one hundred feet (1:1,200), 2 feet. From this it is seen that the scale of six inches to one mile (1:10,560) represents the smallest scale upon which the minimum sized readable symbols are not gross exaggerations of the dimensions of the smaller objects represented. The minor features of the ground, the actual courses of the streams, cultural features,—in fact everything of real importance,—can be shown on this scale. On a scale of one inch to one hundred feet (1:1,200), magnitudes as small as two feet may be shown to scale, hence it is possible on this scale to plot at their scale distances apart the separate rails of a railroad track. On the other hand, on a scale of one inch to one mile (1:63,360), it is impossible to show minor features.

It is only necessary to call to mind the topographical features of any square mile of ground and to remember that the draughtsman has only one square inch upon which to record the information concerning this square mile, when the limitations of a one

inch to one mile map will be realized. The immensely greater detail of a six inch to one mile map results from the fact that the draughtsman has thirty-six square inches in which to record the data, and so with still larger scales.

Although the detail to be represented determines the scale of the map, considerations of cost compel the use of the smallest scale that will answer the requirements of the case. The detail that can be represented clearly on a map varies practically as the area of the map, hence practically as the square of the linear scale. The cost of the field work and the draughting cost will therefore increase very rapidly with the scale. In many engineering maps, the purpose for which they are created will be subserved immediately, but general topographical maps may remain in use for many years. It is particularly in the latter that the cost mounts up for large scales.

It has been seen that on a scale of six inches to one mile (1:10,560), the minimum dimension that can be represented to scale is about eighteen feet. Among the details of immediate importance that properly belong on such a scale are, for example, symbols for vegetation, minor roads and trails, buildings, etc. Much of this is of a perishable nature and changes from year to year. A map that shows such detail becomes rapidly obsolete and requires revision at short intervals, every five years being a usual estimate. On a scale of one inch to one mile (1:63,360), there is only a general representation of the roads, railroads, towns, villages, stream courses, and other similar data, and such a map need not be revised under usual conditions oftener than about once every twenty or twenty-five years. Draughting costs and limitations have therefore an important bearing upon the selection of scales for maps.

Conventional Symbols.

The use of relatively small scales for maps makes it necessary to adopt conventional symbols for the purpose of recording topographical data, in order that the information recorded in a given map area may be as full and clear as possible. Even with the use of conventional symbols, the amount of data that can be recorded clearly in one square inch is strictly limited, because the map must be clear and easily read with the naked eye, possibly in a poor light. The artifices of microscopic representation

or of photographic reduction for issue are therefore of no practical value for increasing the amount of data recorded on a map of a given scale.

Although convenient use of the map imposes an inferior practical limit on the size of the symbols, the execution of the symbols in topographical drawing should vary with the scale of the map. For every scale, such modifications should be made in the size and style of execution of all symbols as will yield for that scale a clear and readable map with the minimum expenditure of draughting time.

Projection of Maps.

In maps of small areas, the spheroidal form of the earth offers no particular difficulty, as the approximation to a plane surface for a small area is sufficiently close that plotting as if it were a plane introduces no serious error. But when extensive areas are to be mapped, the curvature of the earth's surface must be taken into account. Many projections have been devised for the purpose of representing large areas with a minimum of distortion. The topographical draughtsman must be familiar with the principles and practices of the methods of map projection in common use.

The Topographical Draughtsman.

From what has been said, the scope of the knowledge required of the topographer and of the topographical draughtsman is fairly well defined. They must both be familiar with the ordinary methods of map projection, and with the methods of plotting on these projections; with the details that it is possible to show on maps of various scales; with the conventional symbols used in representing the different topographical features; and with the conventions used in lettering on topographical maps.

To this knowledge the topographical draughtsman must add the ability to bring out clearly the important features and to subdue the detail of minor importance in the finished map; familiarity with the minor variations in execution necessary to clearness when working in colored inks and in black; and such skill in execution as to produce a finished map clear in its expression of detail, pleasing in general appearance, and yet done with due regard for economy in draughting time and consequent cost.

Thus a single text may present the subject of topographical drawing in a manner to meet the needs of both the topographer and the topographical draughtsman, since the former may omit largely from his consideration those parts of the text which deal exclusively with standards of execution.

The relation of topographical drawing to topographical surveying will depend upon the extent of the work to be done. In most small surveys, the topographer and the draughtsman will be one and the same. In larger surveys, the best results will require that the field work and the draughting be separated. In extended surveys, such as the United States Geological Survey, the United States Coast and Geodetic Survey, and the United States Lake Survey, where the final aim is the production of an issue of maps by lithographic or engraving processes, the details of the draughting work are modified to conform to the end in view, but the standards of execution should be the same. Clearness and accuracy of representation, beauty of finish, and economy of execution should be the aims in all topographical drawing.

The subject of topographical drawing may be developed under the following heads:

Map Projection.
Instruments and Drawing Materials.
Plotting.
Special Methods for Free-hand Work.
Practice in Topographical Drawing.
Lettering.
Conventional Signs.
Map Drawing.

A large part of topographical drawing consists in the execution of conventional signs, some mechanically, but mainly free-hand. The variations due to scale, to working in colors or in black, and the methods conducive to clearness and economy of time will be brought out in connection with the illustration of the conventional signs and their execution.

CHAPTER II

Map Projection

Ever since it was known that the earth is spheroidal in form, mathematicians and cartographers have been struggling with the problem of representing a portion or all of the earth's surface on a plane. In such a representation, there must of course be some distortion. The object has been to devise some method of projection which would keep the distortion within reasonable limits and at the same time cause the projection to conform to certain desirable conditions, such as correct angles between meridians, equivalence of area, etc.

Such eminent mathematicians as Lagrange, Euler, and Gauss, and others of lesser fame have devoted attention to the subject of map projection, and many different systems of projection have been proposed and used. It is not necessary here to go into the subject deeply. Books bristling with equations and mathematical discussions have been written on it, and even a list of the names of the different projections of sufficient importance to be mentioned and discussed in such treatises would occupy considerable space.*

It is not possible to say definitely that any specific system of projection is better than all others, because for one use a relationship given by one system may be specially desirable, whereas for another use an entirely different relationship might be of greater importance. Thus the Mercator chart, with its special relation of angles, is valuable for use in navigation, although its distortion of areas would make it objectionable for other uses.

Furthermore, a system of projection suited to an area of wide longitude and narrow latitude would not be well suited to an area with these relative dimensions reversed. Thus the persistence

* One such treatise easily accessible is "A Treatise on Projections," by Thomas Craig, published by the Government Printing Office, Washington, 1882, being Treasury Department Circular No. 61, Coast and Geodetic Survey. Methods of projection are described and tables are given for the construction of these projections.

of a variety of systems of projection is based upon sufficient reason. Only those in common use will be described.

Plane Projection.

Small areas, having an extent of not more than about ten miles in latitude or longitude, may be regarded and plotted as plane surfaces, and no serious error will be made unless the scale is very large. In that case, the methods hereafter described for large areas may be used if great accuracy is desired. In plane projection, no preparation of the plotting sheet is necessary other than laying it out in squares when plotting by rectangular coördinates is to be used.

Polyconic Projection.

To explain this system of projection, there will be assumed a sphere with latitude and longitude circles drawn upon it, and a cone tangent to the sphere along a parallel of latitude. (See Fig. 1.) The vertex of this cone will lie upon the prolongation of the axis of the sphere.

Points upon the surface of the sphere are projected upon the interior surface of the cone by lines radial to the sphere. The distortion of the projection of the sphere will be very small for a narrow zone in immediate proximity to the circle of tangency.

If now the cone be developed upon a plane, the circle of tangency will develop into an arc drawn from the position of the vertex as a center, and the projections of all other circles of latitude will develop into arcs with the same center. Longitude circles will be projected upon elements of the tangent cone, and will develop into lines radial to the arcs of latitude. The process just described would result in a *simple conic projection*, with little distortion close to the developed circle of tangency, but with the distortion greater as the distance from this circle increases.

If, instead of projecting a large area of the sphere upon a single tangent cone, only a narrow zone is projected upon it, and succeeding zones are each projected upon a different cone tangent at the middle circle of the respective zones, and if now these various cones be all developed in such relation to each other that the projected central meridian is represented in its true scale length, there results the *polyconic projection*. This projection is of great importance because it is the principal projection used in all of our

great surveys, such as the Geological Survey, the Coast and Geodetic Survey, the Lake Survey, and also in the military surveys of the Philippine Islands.

In the polyconic projection, the lines of the projection form a graticule dividing the sheet into areas practically rectangular

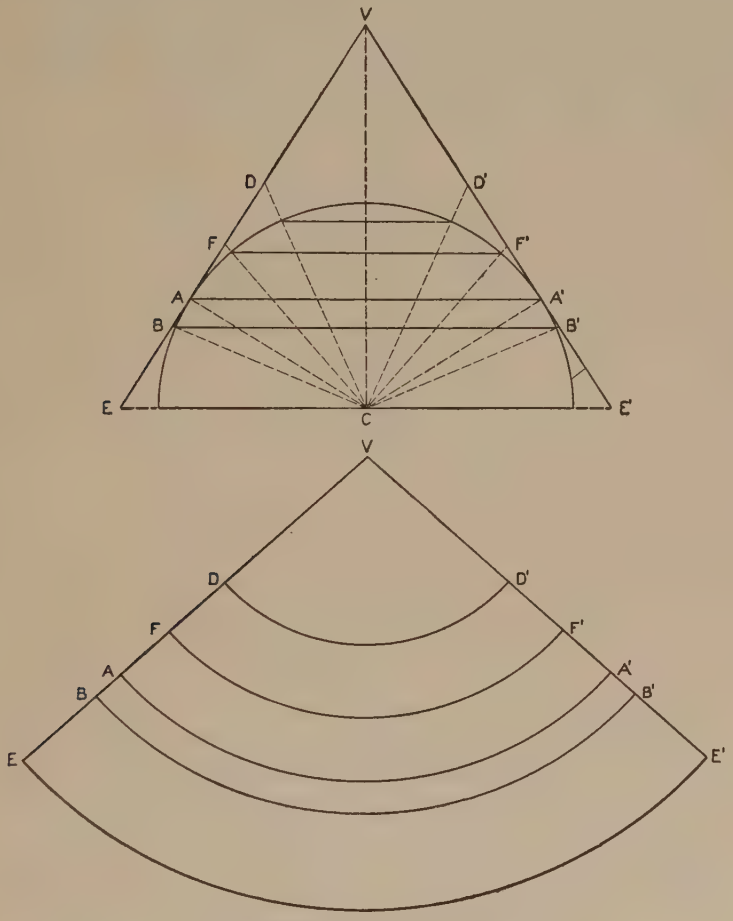

FIG. 1.—Simple conic projection.

in form for large scale maps of small areas, and into quadrilateral areas bounded by curves for small scale maps of large areas.

In the middle of the zones between developed parallels, the maximum of distortion will occur; but if, for map scales of one

inch to one mile and larger, the successive tangent cones be taken at such meridian distances from each other that the plotted length of the central meridian is not more than about six inches, then at no point will the distortion be sufficient to cause any serious error in the projection.

The computation and plotting of the graticule would be very laborious if the computations had to be performed in each case by the methods of spherical trigonometry, particularly with the added complication that the earth is not a sphere but a spheroid.

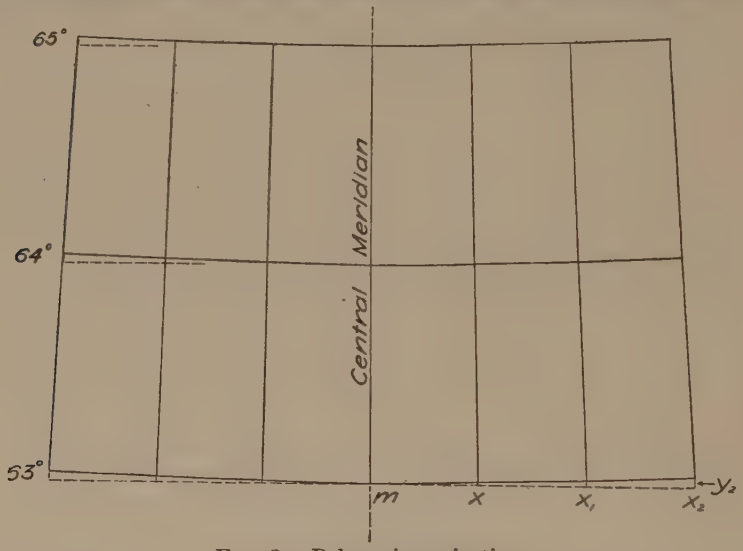

FIG. 2.—Polyconic projection.

As is the case in all computations that must be frequently made, tables have been prepared for the lay-out of polyconic projection sheets. These tables constitute in themselves a volume of considerable size, and no abridgment is of any particular value.*

The general appearance of a polyconic graticule is shown in Fig. 2.

It will be noted that the parallels of latitude appear as arcs of different centers, but with the centers on the central meridian

* See "Tables for a Polyconic Projection of Maps," Department of Commerce and Labor, Coast and Geodetic Survey; Third Edition, Special Publication No. 5, Government Printing Office, Washington, 1910; also "Geographic Tables and Formulas," by Samuel S. Gannett, U. S. Geological Survey, published by the Government Printing Office, Washington, 1916.

produced. The radii of these arcs increase toward the equator, and the equator is represented by a right line in this projection. The central meridian appears as a straight line, and all other meridians appear concave toward it. In the middle portion of a map of large scale, the intersections of the meridians and parallels do not depart much from a right angle. Developed arcs of the parallels appear in true scale length, also the differences of latitude on the central meridian. The distances between meridians on each parallel are equal, but the distances between parallels measured along the meridians increase as the distance from the central meridian widens.

The plotting of a polyconic graticule from the tables is quite simple. The tables give the lengths of arcs of the parallel, and of the meridian, and the coördinates of curvature for all latitudes. A straight line is drawn in the axis of the sheet to represent the central meridian; on this line are scaled off the distances between parallels, and through the points so determined perpendiculars to the central meridian are drawn. The values of the x and y coördinates (Fig. 2) of points in the projection are taken from the tables, and curved lines are drawn through the points thus determined. The vertical lines represent meridians and the horizontal lines parallels. Full explanations of the theory and use of the tables are given in the introduction to the tables. Whoever contemplates the construction of a polyconic projection as a matter of instruction or of practice should provide himself with a copy of one or the other of the tables mentioned.

Bonne's Projection.*

"In constructing a map on this projection, a central meridian and a central parallel are first assumed. A cone tangent along the central parallel is then assumed, and the central meridian developed along that element of the cone which is tangent to it, and the cone is then developed on a tangent plane. The parallel falls into an arc of a circle with its center at the vertex, and the meridian becomes a graduated right line. Concentric

* This description, from "A Treatise on Projections," by Thomas Craig, heretofore cited, is given because the projection has been largely used in topographical maps of European countries except Great Britain. The polyconic projection is used in the British Ordnance Survey.

circles are then conceived to be traced through points of this meridian at elementary distances along its length. The zones of the sphere lying between the parallels through these points are next conceived to be developed, each between its corresponding arcs. Thus all the parallel zones of the sphere are rolled out in their true relation to each other and to the central meridian, each having in projection the same width, length, and relation to the neighboring zones as on the spheroidal surface. As there are no openings between consecutive developed elements, the total area is unaltered by the development. Each meridian of the projection is so traced as to cut each parallel in the same point in which it intersected it on the sphere."

Mercator's Projection.

A *cylindrical* projection results from projecting the meridians and parallels of a sphere upon the inner surface of a cylinder tangent at the equator, and then developing the cylinder. Both meridians and parallels appear as right lines.

In the *Mercator chart*, much used in navigation, the cylindrical projection is modified by spacing the parallels of latitude so that the represented lengths of degrees of latitude and longitude at any point on the chart have the same relative values as the actual lengths at the corresponding points on the earth's surface. The chart is convenient for ascertaining the compass course to be sailed in going from one point to another. The distances are badly distorted.

Bonne's and Mercator's projections have been described because they are used to a considerable extent in map and chart work. The methods of constructing these projections and the necessary data for constructing them will be found in the *Treatise on Projections* heretofore cited. The topographical draughtsman will be chiefly concerned with the plane and polyconic projections.

CHAPTER III

Instruments and Drawing Materials

It is assumed that the student who desires to take up topographical drawing is already familiar with the use of the ordinary instruments employed in mechanical drawing. Such familiarity may be acquired by the ordinary college course in general drawing, or by practice guided by a good text-book on mechanical drawing.

There are some special points even in the use of the ordinary instruments which should be noted. There are also a number of special instruments used in topographical drawing, facility in the use of which must be acquired. Descriptions and illustrations of the instruments mentioned will be found in any catalogue of drawing instruments.

Drawing or Ruling Pen.

Thorough command of the drawing pen, particularly in connection with railroad and irregular curves, is necessary.

In topographical drawing, due to the fine texture of the work necessary in recording much data in a small space, and more particularly to the necessity of subduing relatively unimportant data, it becomes essential to draw finer lines than are ordinarily used in mechanical drawings. The topographical draughtsman should therefore be able to command the finest line that it is practicable to draw uniformly with the drawing pen. The pen itself should be sharp and in good condition for use. In drawing a very fine line, the pen will not work properly and feed ink regularly if the blades are in actual contact at their points. The blades should be set barely out of contact. This can be done best by setting the pen before it is filled with ink, holding it up toward the light and setting with the smallest possible open space between the points of the blades. A little practice will enable the draughtsman to set the pen quickly and finally in this way. The setting should not be disturbed after filling

with ink unless a trial line shows the setting to be manifestly wrong. If set with ink in the pen, there is no way of telling whether the blades are in actual contact. If they are, the pen may work all right on a trial line while the ink is fresh, but will cease to feed as soon as the ink thickens a little under exposure to the air. If the ink fails to feed in the middle of a fine line, it is very difficult to complete it without a noticeable irregularity. It is therefore much better to be assured of a setting that will avoid such a contingency.

In this text, the term *very fine line* will be used to designate this finest line that can be drawn, in contra-distinction to the ordinary "fine line," which also is used in topographical drawing.

Contour or Curve Pen.

This is a special instrument sometimes used in drawing contours, more particularly on large scale maps where the execution is in bold lines. In such cases, the production of heavy lines of uniform width and pleasing appearance would be impossible by the use of an ordinary pen free-hand.

The contour pen has blades so curved as to place the point of the pen off of the axis of the pen handle. The blades are mounted on a spindle which extends through the handle and has locking nuts on the farther end. By the use of the locking nuts the rotation of the spindle may be prevented, and the contour pen then serves as a poor substitute for a drawing pen.

For use in drawing contours, the locking nuts are loosened enough that the spindle will turn freely in the handle. Care should be taken that no more play is allowed than is necessary for free rotation. The locking nuts are then set up. The pen should be examined carefully and tested to see that the rotation is free and that there is no roughness in the turning, otherwise the pen is unfit for use. The spindle should be oiled occasionally.

If the rotation of the spindle is free, the eccentricity of the point will cause the pen to turn and follow the motion of the hand, the blades always parallel to the direction of motion, thus drawing a clean and uniform line of the width determined by the setting of the pen.

The contour pen must be held with the *handle perpendicular to the plane of the paper*. This is important, as otherwise the pen will not turn freely to follow the motion of the hand, but will have

a tendency to "skid" or jam in making changes of direction. In addition, one blade of the pen will leave the paper when the line is drawn in a direction at right angles to the inclination of the pen handle.

There are several points to be learned in using the contour pen. Due to the slight looseness of the spindle when it is set so as to turn freely, it is difficult to set the pen down on the paper or remove it from the paper without a slight lateral jump resulting in an imperfection in the line. To start a line, hold the pen with the handle vertical and turn the point in the proper position to

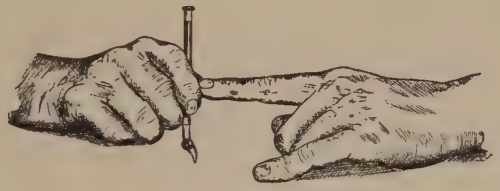

FIG. 3.—Use of the contour pen.

trail in the direction the line is to be drawn at its beginning. Place the right hand in the position for drawing, the left hand resting firmly on the paper, the thumb and little finger extended, the second and third fingers turned under. Now touch the thumb or forefinger of the right hand with the extended forefinger of the left hand, and the pen can be lowered upon the paper steadily and at the exact point desired. (See Fig. 3.) A similar method is used in lifting the pen from the paper. If the tracing cloth has a tendency to buckle, the left hand can be used in this position to hold it in contact with the drawing board at the point where the line is to be started or stopped.

The line is drawn by such a motion of the hand as will cause the point of the pen to follow the line to be inked. No particular difficulty will be experienced in following curved lines unless the bends be of very short radius. The motion for sweeping curves is the same as that in drawing long lines with a drawing pen. But in turning sharp bends in the contour lines, the little finger ceases to slide upon the paper and the change in direction is made by an extension or contraction of the muscles of the hand and fingers similar to the finger movement used in stopping at a point with the drawing pen.

In making sharp bends with the contour pen, it is necessary to move the hand so that there will be actual travel of the point of the pen at all times, and not a mere turning of the point in place, otherwise an unsightly blemish will be made in the line. Experiment will determine the minimum diameter that can be negotiated successfully with the contour pen to be about one-sixteenth of an inch, or perhaps a trifle less. If the bends are sharper, the line is discontinued and resumed beyond the bend, the space being filled in free-hand with a pen that will match the weight of the line drawn.

Railroad Pen.

This is a special double drawing pen for drawing parallel lines. It is provided with a set screw for adjusting the distance between the lines drawn. Although the pen has the advantage of keeping a fixed distance between the two lines drawn, it has many counterbalancing disadvantages, among which are difficulties in manufacture such that the pen is rarely satisfactory from a mechanical standpoint. Its use is not recommended. Parallelism of the lines can be secured by the ordinary methods, and the eye or other means should be relied upon to maintain uniform spacing.

Beam Compass.

This is an instrument for drawing circles of greater radius than can be drawn with the ordinary compass and extension bar. It is used in topographical drawing principally for the accurate construction of perpendiculars in the plotting of projection sheets.

Proportional Dividers.

These are useful in topographical drawing for transcribing data to a map of a scale larger or smaller than that of the field sheet, and for enlarging and reducing maps.

Pantograph.

This is an instrument comprising a frame containing an adjustable parallelogram, and so designed that when any figure is passed over by its tracing point the copying point will describe an exactly similar figure on a larger or smaller scale. The scale of the reproduction may be varied by the adjustments of the instrument. The pantograph is very useful for enlarging or reducing maps. For great accuracy, the suspended form of pantograph should be used.

Protractor.

The protractor is essentially a graduated circle or semicircle, with the center accurately marked. In one form, the circle is printed or stamped on a sheet of paper or celluloid. The form commonly used for plotting in topographical drawing is made of German silver and accurately graduated. The best type has a pivoted arm and vernier by means of which the desired angle may be set off and drawn. (See Plotting, Chapter IV.)

Scales.

For plotting on scales of 10, 20, 30, 40 , 50, and 60 feet to one inch (1:120, 1:240, 1:360, 1:480, 1:600, and 1:720) the ordinary engineers' scale, flat or triangular, may be used, in which case the smallest subdivisions represent single feet. But these are not usual scales for map work, and it is generally more convenient to construct a suitable working scale. For this purpose the best available mounted drawing paper or three-ply Bristol board should be used. To construct such a scale, a distance in even hundreds or thousands of feet is chosen so that the scale length will be equal to the longest distance to be plotted. Usually six inches will suffice for ordinary plotting. The actual scale length of this distance is then accurately calculated.

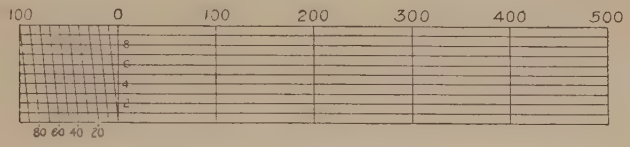

FIG. 4.—Diagonal scale.

For example, for a map scale of six inches to one mile (1:10,560), a ground distance of 6,000 feet is chosen. The calculated map length of 6,000 feet is $\frac{6,000}{5,280} \times 6 = 6.818$ inches approximately. This distance is laid off as accurately as possible upon a line, and by means of an auxiliary oblique line the distance is divided into six equal divisions each representing 1,000 feet. The left-hand division is then further subdivided in like manner into ten equal parts each representing 100 feet. Ten lines are now ruled parallel to the original line and at convenient equal distances apart, and a diagonal scale drawn whose least direct read-

ing is 10 feet. From the diagonal extension, distances may be taken off by estimation to the nearest foot.

Such a scale is shown in Fig. 4. It is valueless unless drawn with extreme care and accuracy, and inked carefully in the finest possible line. The scale should be carefully handled and protected as much as possible against moisture. Distances are taken off with dividers, and even with the utmost care use will mar the lines. When the scale becomes unserviceable through wear, a new one should be drawn.

Curves.

The irregular curve is frequently used in topographical drawing, and the topographical draughtsman must be especially skillful in its use. In drawing a line with the irregular curve, the handle of the drawing pen must be rolled between the thumb and fingers so as to keep the blades of the pen always parallel to the edge of the guide. Successful use of the irregular curve requires the ability to make accurate and smooth junctions with lines already drawn. Such junctions can be made only by knowing accurately the clear space between the edge of the guide and the line as drawn with the normal holding of the pen, supplemented by carefully watching the nibs of the pen by looking *along* the edge of the guide as the point is making contact with the paper, and slanting the pen handle slightly outward or inward in order to insure perfect alignment. In drawing heavy lines, it is better to watch the outer blade of the pen and align it accurately on the outer edge of the line than to watch the point of the pen as a whole.

Railroad curves may occasionally be useful in drawing the curved lines of a small-scale projection sheet. For the very flat curves of large-scale projections, the curvature of the line can be secured by using a straight-edge and varying the inclination of the handle of the pen so as to cause its point to pass through the determined points on the line to be drawn. In this method, the slant of the pen at each point is ascertained by trial, and the slant changed gradually to conform as the line is drawn.

Section Liner.

The section liner may be used for ruling the parallel lines which constitute the conventional symbols for cultivated land

and for swamps or marshes. The topographical draughtsman should be able to depend upon eye-spacing for this work ordinarily, but cases may occur, in extended marsh areas for example, where the use of the section liner is almost indispensable.*

Straight-edge.

For use in laying out projection sheets, a steel straight-edge is necessary. The length will be determined by the longest dimension of the projection sheet used. A length of 36, 48, 60, or 72 inches will answer the requirements of various cases. A standard meter scale (steel) is required in a thoroughly equipped topographical draughting office. It is needed in laying out projection sheets, and is very useful for the tests of paper for shrinkage and distortion.

Paper Weights.

These are needed, particularly in working on tracing cloth, to keep the paper or cloth stretched flat at the point where the draughtsman is working. Otherwise the looseness of the tracing cloth in large sheets is very troublesome in working free-hand on conventional symbols and in using the contour pen. The best form of paper weight is a small canvas bag partly filled with fine shot.

Paper.

It is apparent that all of the refinements in accuracy used in making polyconic projection sheets and in the calculation and plotting of the positions of points will be wasted unless the very best quality of drawing paper is used. For ordinary work,

* As an instance, in the Military Survey of the Philippine Islands, the area mapped included the great Candaba Swamp in central Luzon. This marshy area was roughly twenty miles long from north to south, and from five to eight miles wide. The map sheets were ten minutes in latitude by twenty minutes in longitude, the scale of the map being two inches to one mile. The plotted swamp area extended entirely across one map sheet and halfway across each of the two adjacent sheets.

The draughting office did not possess a section liner, and it was found by test that none of the ten or twelve Filipino draughtsmen, although some of them were exceptionally competent, could be relied upon to do by eye or measurement an acceptable job of section lining on the swamp, the difficulty being aggravated by an irregular outline. These sheets were laid aside unfinished until a section liner could be procured from the United States.

a good quality of mounted paper will suffice. For the office record map of accurate surveys, the very best obtainable mounted drawing paper, or specially prepared double mounted paper (unchangeable drawing board), will be found upon test to be none too good. In fact, even with the best paper, the shrinkage and distortion will be found to be troublesome factors if the climatic conditions are unfavorable, as is the case in tropical countries. Each new shipment of paper should be tested for shrinkage and distortion before being put into use. To make such a test, lines are drawn in several different directions on a test sample of the paper, and distances laid off on these lines with the standard meter scale and accurately marked. This sample sheet is then subjected to the normal exposure in the draughting room, and the marked distances are tested to see whether or not there is undue shrinkage or distortion. It will be found that there is normally more change in the direction of the length of the paper as made in rolls than in a direction across the grain of the paper.

Even in the best paper, the shrinkage and distortion will be noticeable under severe conditions. The paper should be protected as much as possible from dampness. After being once unrolled and flattened, mounted drawing paper should be kept flat. The double mounted paper is shipped flat and not meant to be rolled up. In fact, the paper is so stiff that it would be seriously injured by being rolled.

Transfer Paper.

Transfer paper may be made by grinding a soft pencil on a file and rubbing the resulting pencil dust on a piece of thin paper by means of a small pad of cloth. Or the pencil itself may be rubbed over the surface of the paper and the lead then more evenly distributed by rubbing the paper with a piece of cloth.

Transfer paper is useful for transferring topographical data from the field sheets to the record map, or from one field sheet to another, provided that the data to be transferred is on fairly thin paper. The faint lines produced by the transfer paper are gone over in pencil or ink.

Tracing Paper.

Tracing paper may be used for plane-table sheets in topographical survey work. For such use, the paper must be heavy and

tough, and should not spot or buckle badly under the action of water. A high degree of transparency is not essential or even desirable. A sheet of white paper should be used under the tracing paper on the plane table so that the plotted lines will show distinctly.

Although tracing paper is by no means ideal for plane-table sheets, its use offers several important advantages. The lines of the projection sheet and the control points plotted thereon can be transferred directly to the plane-table sheet by tracing. The connecting topography of one sheet may be traced on the adjacent sheets, a great convenience in field work. The transfer of the data from the plane-table sheet to the projection sheet in the compilation of the field work is greatly facilitated by the transparency of the tracing paper, which enables the plane-table sheet to be adjusted accurately in position for the transfer.

Tracing Cloth.

Of all the materials with which the topographical draughtsman has to deal, tracing cloth is perhaps the least satisfactory. The tracing of a large topographical map sheet is a long and tedious operation, and to the last the surface must be preserved uninjured so as to take the finest line. Prolonged exposure of the tracing cloth is almost sure to lead to shrinkage, extension, and distortion. Any buckling makes the tracing cloth difficult to work on. All that can be done to avoid these difficulties is simply to reduce the exposure to air and wear to a minimum. As soon as the projection lines are traced, and the roads, railroads, etc., constituting the main framework of the sheet are drawn in, the whole of the tracing cloth should be covered over with sheets of heavy paper about eighteen inches square. One of these sheets is removed to provide a working area. A working sheet is made by cutting an opening about six or eight inches square in the middle of a sheet about thirty inches square. Through this opening as much as possible of the draughting work is done. The balance of the working sheet serves to cover the area exposed by the removal of one of the cover sheets. The working sheet and the cover sheets are shifted around as necessary, and the tracing cloth is exposed only in the small area where work is being done.

Inks.

Black, green, blue, and brown inks will be required. The ordinary waterproof drawing inks may be used, and will be found generally to be the best.

For certain uses, a black ink thinner and more fluid than the prepared ink is desirable. This may be obtained by thinning the prepared ink with ¼ to ½ its volume of distilled water. The bottle containing the thin ink should be specially marked, as it is not thinned enough to be readily distinguishable from the regular ink. If Chinese or India stick inks are used, the two grades of black ink are secured by regulating the preparation of the ink.

The green ink used should be a bright but not yellowish green. It can be prepared from water colors by the use of gamboge and Prussian blue, regulating the relative quantities so as to produce the desired color. This ink will give trouble on account of the tendency of the blue to settle, not only in the bottle, but in the pen while in use. The prepared ink will be found more satisfactory. The commercial green ink is too dark a green in color, and should be lightened by the addition of a small amount of yellow ink. Blending of the commercial inks does not introduce any tendency to separate or settle.

Blue ink may be prepared from water color (Prussian blue), but again there will be found the tendency to settle. If there be any delay in drawing lines, the color will settle to the point of the pen and the first part of the line drawn will be darker in color. This necessitates the constant use of an auxiliary piece of paper on which short lines should be drawn before starting inking, after even a slight delay. Again the prepared ink will be found more satisfactory. A bright sky-blue ink should be used. If the commercial ink is too dark in color, as is usually the case, the color may be lightened by thinning the ink with distilled water.

The brown ink should be a reddish brown, not too dark in color. This may be prepared from burnt sienna water color, and this color will be found more satisfactory than the others when prepared from water color. Even in this color, the prepared ink will be found more satisfactory. The commercial brown is too dark in color. A good brown may be prepared by mixing commercial prepared inks in the proportion of one part brown, one part orange, and two parts scarlet.

None of the water color inks are waterproof, but this quality is not essential on a drawing which will receive the care properly bestowed upon a map worthy of being executed in colors.

Water Colors.

Methods of rendering topography in water colors have been devised, and they are sometimes described at length in connection with the subject of topographical drawing. But water color methods have largely gone out of use in topographical drawing, just as they have in mechanical drawing, and the methods are not deemed of sufficient importance to be described here. The draughtsman must develop a high degree of skill to become proficient in this class of work, a talent not worth developing in view of its very limited use.

A special use of water colors will be described in connection with the subjects of water-lining and contouring.

CHAPTER IV

Plotting

The position of a point on the surface of the earth is fully known when the latitude and longitude of the point are known. Measurements from this point as an origin should be referred to a standard direction which may be determined or reproduced at any time. This standard direction is called the true meridian.

For surveys purely local in character, the absolute position of points is immaterial, and reference of directions to the magnetic meridian may be sufficient. On account of the variation of the direction of the latter, however, it is customary in almost all cases to refer directions to the true meridian. Such directions are called true azimuths.

A point may be considered as known when its plotted position is assumed, and through this assumed position a line is drawn to represent the direction of the true meridian. Other points become known when plotted in azimuth and scale distance from the assumed point.

In topographical survey work, the position of an unknown point may be determined (1) by the measurement of angles from two known points, as in triangulation or in locations by intersection; (2) by the measurement of the azimuth and distance from a known point; and (3) by the "three-point" method of location.

A point may be plotted (a) by drawing through a known point a line making an angle with the assumed meridian equal to the measured azimuth of the line to the unknown point, and upon this line laying off the scale length of the measured distance between the known and unknown points; (b) by drawing through each of two known points a line making with the meridian through that point an angle equal to the measured azimuth of the unknown point, in which case the intersection of the two lines determines the plotted position of the new point; and (c) by calculating from the observed data the coördinates of the unknown point with

reference to the assumed coördinate axes, and plotting the point from these axes.

The first and second methods of plotting are practically the same, so that the choice is really between plotting by polar coördinates and by rectangular coördinates.

Polar Coördinates.

In plotting by polar coördinates, a point is assumed as the plotted position of the origin of the survey. Either by an approximate sketch or from knowledge of the shape and extent of the area to be plotted, the position of the origin is so assumed that the plot as a whole will be properly located on the sheet.

A line is drawn through the origin to represent the direction of the true meridian. Unless there are valid reasons for doing otherwise, the direction of the plotted meridian should be parallel to one edge of the paper, so that the plot or map is oriented with its north point at the top of the sheet.

Azimuths are plotted from the assumed meridian by means of a protractor. If a simple circular protractor is used, the angle is measured as accurately as possible by interpolation within the least reading of the graduation, and the direction marked by means of a needle. A line is then drawn through the point thus marked and the plotted position of the assumed origin, and upon this line is measured off the scale distance to the new point.

If an arm protractor with vernier is used, the angle is first set off by means of the graduation and vernier. The zero line of the protractor is then placed accurately over the meridian with the center mark exactly at the plotted position of the origin. The protractor arm is now pressed firmly down in contact with the paper and the line drawn. It is then prolonged backward to the center and the distance to the new point set off on the line.

The protractor arm is usually bevelled to a thin edge, but even so the position of the line drawn will vary slightly with the manner of holding and method of sharpening the pencil. The position of the pencil which gives the most accurate plotting of the angle should be determined by test, and that position subsequently used. Such a test can be made by plotting an angle of 22½ degrees four times successively and testing the result

with a 90° setting of the arm. If the four accumulated plottings overrun or fall short, the necessary change in the holding of the pencil is made and the process repeated until a satisfactory result is achieved. Thereafter lines should be drawn with the holding of the pencil thus determined.

After all locations from the origin have been plotted, including that of the next station, a meridian is drawn through the new station parallel to the assumed meridian, and the process of plotting repeated.

In plane-table plotting, the directions of all shots are determined by the pointing of the alidade, and the plotted line results from drawing a line with the edge of the alidade as a guide. Accurate results require that the line shall always be drawn in the same relation to the edge of the alidade. This end is best achieved by drawing lines with the pencil slanting outward so that the point is in contact with the alidade at the surface of the paper, so that there is no visible space between the line drawn and the edge of the alidade. This method will also be found to be the best for drawing the lines accurately through the plotted positions of the stations. If a needle is used on the plane table for the purpose of marking the station, the holding of the pencil must be adjusted so that the line drawn will be the same distance from the edge of the alidade as is the center of the point marked by the needle.

The disadvantage of the polar coördinate method of plotting lies in the fact that the angles cannot be set off as accurately as they are measured in the field, and the plotting errors are cumulative and affect all points subsequently plotted.

Rectangular Coördinates.

To get rid of the cumulative errors of plotting by polar coördinates, the method of plotting by rectangular coördinates is used. As a preliminary to plotting by this method, rectangular coördinate axes are assumed and the coördinates of all points are calculated. One of the axes is preferably assumed parallel to the meridian, except in the case of plotting city surveys where the streets do not run north and south and east and west. The origin may be assumed at any position, distances east and north of the origin being called positive, and west and south of the origin negative. It is preferable, how-

ever, to select an origin south and west of the area to be plotted, so that all coördinates will be positive.

The calculation of the coördinates may be carried out to any desired degree of accuracy. Tables for the purpose are accessible, or an ordinary table of sines and cosines may be used. In any case, the calculation should be carried out with sufficient refinement that the error in the coördinates will be much smaller than the plotting limit for the scale used.

The sheet is prepared for plotting by ruling two sets of equidistant and parallel lines perpendicular to each other, the sides of the squares thus formed having a scale length of 100, 1,000, or 10,000 feet, depending upon the scale to be used. Upon this graticule the points are plotted according to their calculated coördinates. The hundreds, thousands, or tens of thousands of feet in the coördinates of any point are shown by the graticule itself. The remaining distances are plotted from the corner of the appropriate square as an origin, using the diagonal working scale.

In this method of plotting, the maximum error is that of the plotting of a single point, since each point is plotted independently from the origin.

Plotting on Polyconic and Other Projections.

The following methods of plotting apply only to those forms of projection in which there is comparatively little distortion in area and consequently in distances. These conditions are fulfilled by all of the forms of projection in common use for topographical maps.

In any form of projection which takes into account the curvature of the earth, the latitude lines of the graticule represent pre-determined parallels of latitude. All sheets of a given latitude are similar. The projection sheet becomes fixed in position on the earth's surface when the latitude lines are numbered to correspond to the latitude for which they are calculated, and the longitude lines are numbered to correspond to the particular position in longitude to be covered by the projection sheet.

The problem of plotting on a projection sheet is that of determining in as simple a manner as possible the positions of the calculated points with respect to the lines of the graticule. The latter are usually so drawn that direct plotting in proper relation to these lines is not simple. The most accurate plotting would

require that a portion of a new latitude line be drawn corresponding to the latitude of the point to be plotted, in a manner entirely similar to the construction of the latitude lines of the projection sheet. Upon this line would then be set off a distance corresponding to the longitude of the point to be plotted. The amount of labor involved in such a method of plotting would be out of proportion to the results achieved in the way of accuracy, and for that reason an approximate method is normally used.

Usually only the more important control points are plotted on the projection sheets. The latitudes and longitudes of these points are first calculated to a degree of accuracy well within the plotting limit for the scale of the projection sheet. Thus if the projection sheets are on a scale of six inches to one mile (1: 10,560), the graticule would be drawn with lines for each minute of latitude and longitude, so that the distance between parallels would be about six inches. The distance between meridians would be some lesser distance depending upon the latitude, since arcs of longitude diminish toward the poles.

On this scale, one-tenth of a second in latitude would be represented by a distance of about one one-hundredth of an inch. The distances in longitude would be smaller. It will therefore be sufficient to calculate the latitudes and longitudes of points to the nearest tenth of a second when plotting on a scale of six inches to one mile, and to proportionate degrees of accuracy for other scales.

To illustrate the method of plotting, let us assume one of the approximately rectangular areas of a polyconic projection graticule (Fig. 2). It is to be noted that the meridians are converging and slightly concave toward the central meridian, and that the arcs of the parallels of latitude are of different radii and not concentric. Hence the distance between parallels measured on the meridians varies, as also the distance between meridians measured on the parallels. The problem of plotting is therefore that of interpolating between two sets of curved lines, the distance between lines varying in both sets. The method of plotting commonly used assumes that for short lengths these lines of the graticule may be regarded as parallel right lines, and that interpolation can be effected along a diagonal line provided this diagonal line be not too oblique to the lines of the graticule.

The method of plotting may be explained by reference to Fig. 5. Assuming a scale of six inches to one mile (1:10,560), and that points are to be plotted in latitude and longitude to the nearest tenth of a second of arc, a special plotting scale is prepared whose total length is equal to or very slightly greater than the

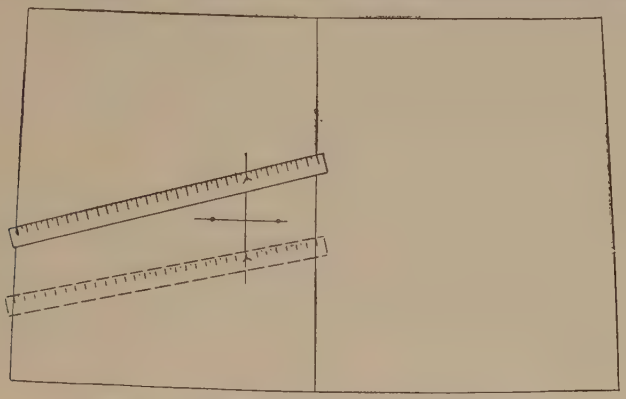

FIG. 5.—Plotting on polyconic projection.

longest side of any of the subsidiary figures of the graticule. This scale is divided into sixty equal parts, each representing approximately to scale one second of arc. A diagonal line is drawn in the end division of the scale, subdividing it into ten equal parts each representing approximately to scale one-tenth of a second of arc. The detailed construction of such a scale is shown in Fig. 6

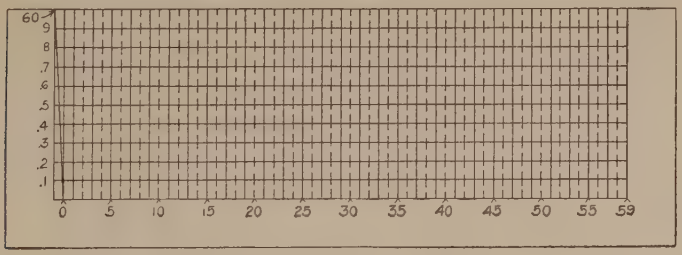

FIG. 6.—Scale for plotting on polyconic projection.

As an example of the use of this scale to interpolate the position of a point in longitude, the odd seconds and tenths of a second are taken from this scale by means of a pair of dividers. The scale is then set in the approximate latitude of the point to be plotted, and adjusted in position so that its extremities are accurately

on the meridians of the graticule. (See Fig. 5.) The dividers are now applied to the edge of the scale and the proportionate distance corresponding to the odd seconds of longitude set off. The process is repeated at a short distance north or south of the first point marked, so that the two points will include the latitude of point between them, and the two points are joined by a short line. The line thus drawn will be a very close approximation to the short arc of the meridian containing the point. The line approximating an arc of the parallel is determined in an exactly similar manner. Where the two short lines thus determined intersect is the plotted position of the desired point.

Near the equator the same scale may be used for plotting in latitude and longitude, for the true lengths of the arcs of the meridian and parallel are nearly equal. But beyond latitude about 15°, the arcs of longitude begin to depart in length from the arcs of latitude sufficiently that it will be necessary to prepare separate scales for interpolation in latitude and longitude. Each is prepared equal to or slightly greater in length than the longest corresponding line of the graticule of the projection sheet.

Where a comparatively small amount of plotting of points on projection sheets is contemplated, the draughtsman will find it necessary to prepare his own scales as just described. If the amount of plotting is large and continuous, as is the case in some of the larger government surveys, special metallic scales of suitable lengths and conveniently graduated to the smallest desirable subdivisions, are used.

The methods described apply to the plotting of points in latitude and longitude, more especially to the control points of a survey. Control traverses connecting these control points may be plotted on a piece of tracing paper, either by polar coördinates or by rectangular coördinates. The total error of the traverse including the distortion of the projection is thus determined, and the total adjustment of the error is made by parallel and proportionate correction or by other methods as described in works on surveying.

The corrected and adjusted traverse is then transferred to the projection sheet by pricking through or by transfer paper.

When the projection graticule is transferred with its control points to the plane-table sheet, the distortion of the projection is considered as combined with the ordinary errors of closure on control points, and adjustment is made for both at the same time.

CHAPTER V

Special Methods in Free-hand Drawing

It has been pointed out that the aims in topographical drawing should be clearness and accuracy of representation, beauty of finish, and economy of time in execution. The methods conducive to economy of time will be considered later.

Clearness of representation demands that detail of minor importance shall be subordinated and shall not be allowed to smother the important information on the map. This subordination can be achieved without special difficulty when working in colors, as the colors lend themselves well to this end. But when working in black alone, as is the case in preparing the tracing of a map, a principal factor in the subordination of minor detail lies in the use of very fine lines.

Beauty of finish requires, among other things, accuracy and regularity in the execution of small lettering and of small symbols in fine lines. This result can be achieved only through a delicate touch and a steady hand.

A delicate touch requires a light grasp of the pencil or pen. A steadiness of hand which can, unaided, produce a smooth and uniform line with a fine pointed pen is a valuable asset in topographical drawing; but if there is any muscular tremor, it can be largely obviated by the methods of work now to be described. These methods are recommended for use *only* in case it is found impossible to secure satisfactory results without them.

If the pen be held in the hand in the drawing position, it will be found where muscular tremor or unsteadiness exists, that it is wholly in a direction at right angles to the line of the forearm, and that if the right hand be supported by the left so as to prevent lateral motion, a perfectly steady position will thus be secured. To be of assistance in free-hand drawing, this support must be given by the left hand in such manner as to allow some freedom of motion to the right hand, otherwise no useful result will be achieved. Perfect steadiness of position is useless for drawing if coupled with perfect immobility.

There are several different methods of supporting the right hand by the left while still allowing sufficient motion to enable work to be done. The best of these will be described, and if support is found to be necessary, all of the positions should be tried to find the one which is best suited to the conformation of the hand and to the individual peculiarities of the draughtsman.

The best of these methods of supporting the right hand is shown in Fig. 7. In this position, the right hand holds the pen or pencil in the normal position. The tips of the left thumb and fore-

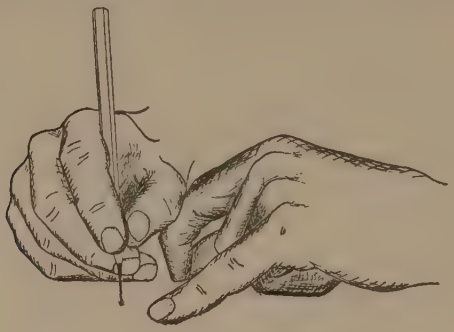

Fig. 7.—Position for free-hand work.

finger are placed together, the thumb straight and the first and second joints of the forefinger flexed. The second and third fingers are doubled under out of the way, and the little finger is extended. In this position, the left hand is placed with the little finger and the joined thumb and forefinger resting firmly on the paper, the weight of the forearm supported on the muscle near the elbow. The left hand is now slid up in contact with the right hand, the second joint of the forefinger touching about halfway between the first and second joints of the right thumb. In this position it will be found that the left hand gives satisfactory support to the right hand, and that by raising and lowering the left wrist the forefinger can be kept in contact with the right thumb and yet allow sufficient motion of the right hand to permit the execution of small letters or symbols. The extended little finger falls near the point of the pen and is useful for keeping the paper or tracing cloth pressed down in contact with the drawing board. This latter point is the chief advantage of this position over the others to be described.

The left hand may be closed and placed firmly upon the paper resting upon the second joints of the fingers. The thumb is extended with its tip touching the first joint of the right thumb. The motion of the right hand can be followed more freely in this position than in the first position described, but the support is not quite as satisfactory. If the little finger of the left hand be extended to press down the paper, it robs the position of the left hand of much of its steadiness.

The left hand may be placed in a position similar to that described in the use of the contour pen (see Fig. 3), the tip of the left forefinger touching the thumb nail or side of the first joint of the forefinger of the right hand. In this position, the necessary follow-up is secured by raising and lowering the left wrist.

The left hand may also be closed as a fist and slid up until the forefinger touches the right thumb. The support is excellent, but there is considerable difficulty in following up the necessary motion of the right hand.

Enough variations of the position have been described to fit most cases, but there are many other positions, some one of which may fit the conformation of the draughtsman's hand better than any of those described. The object to be attained is to rest the left hand in a steady and firm position, to then make some contact with the right hand that will prevent tremor, and at the same time have enough elasticity in the position of the left hand to enable it to follow up the motion of the right hand through a small range.

These aids slow down the work and are valuable only for those who have difficulty in controlling the motion of the right hand. They should be used only when necessary. It may be found, for instance, that there is difficulty only in making strokes in certain directions, notably in the horizontal strokes in lettering. In such cases, the left hand should be called into use as a support for those strokes and for no others.

CHAPTER VI

Practice in Topographical Drawing

Note.—Chapters VII–XI are for reference in this connection.

The topographical draughtsman must master the elements of his art,—lettering in the various conventional alphabets, and the execution of the various conventional signs. There is no short cut to such mastery; it must be gained by practice.

To lend variety to this practice, work in lettering should alternate with work in the execution of conventional signs.

Lettering.

Although single-stroke lettering will answer many of the requirements of the topographer, but little of the lettering on finished maps is done in this alphabet. Proficiency in single-stroke lettering requires:

1. Study of the forms of the different letters of the alphabet, both capital and lower case;
2. Practice in the separate strokes that go to form the letters of the alphabet;
3. Practice in the execution of the individual letters; and
4. Practice in spacing and arrangement of letters in words and of words in sentences.

If the student requires practice in single-stroke lettering, Fig. 15 will form a sufficient guide. In that figure are shown the order and direction of the strokes. Practice in pencil should precede practice in ink. It will be found advantageous in the pencil practice to use a 6H pencil with a long and very sharp conical point. A light touch must be used, so that erasures may be made easily and completely.

For the more elaborate forms of lettering, such as the Roman and Roman italic (see Figs. 9 and 10), the letters must be outlined in pencil in light lines. The outlines are then inked in fine lines free-hand and the shaded portions filled in. Again in the pencil work a fine conical point and a light touch must be used.

The successive stages in the execution of Roman lettering are

shown in Fig. 16. The same methods of execution may be applied to Gothic lettering when the best possible results are desired.

The topographical draughtsman must master the alphabets shown in Figs. 9, 10, 11, 12, and 14, as they are all required by the conventions of lettering on topographical maps. These alphabets should be taken up in turn. In each, practice should be had in the execution of the individual letters until the form is firmly fixed in the mind and reasonable proficiency in execution reached. The final practice in each alphabet may well take the form of a reproduction in pencil and then in ink of the figure used to illustrate the alphabet in the text. The discussion concerning the use of each alphabet should be studied in connection with the practice of that alphabet.

Conventional Signs.

Some of the conventional signs—principally those representing the works and structures of man—are executed mechanically. In these, the student familiar with mechanical drawing will need no more than a single repetition of them to impress the form upon the mind. Others of the conventional signs—principally those representing natural features and the various classes of vegetation—are executed free-hand, and in these practice will be necessary.

This practice should comprise:

1. Study of the form and practice in the execution of the individual conventional signs; and
2. For vegetation symbols, practice in the variations and combinations of these symbols as applied to areas covered by that class of vegetation represented by the symbol under consideration.

Thus the special symbol which is used to represent grass must be practised until the individual symbol can be satisfactorily executed, and then the variations and combinations of the grass symbol used to represent an area covered by grass must be studied and practiced.

The most satisfactory method of practice in the execution of conventional signs is to carry along simultaneously two practice sheets; an informal or scratch sheet on which the preliminary practice of the signs is done, and a formal practice sheet on which the signs are executed as a final test or proof of proficiency.

The plates of Chapters VIII, IX, X and XI have been designed with this method of practice in view. Each figure represents one class or division of conventional signs, and can be reproduced in an area 2″x2″, 2″x4″, 4″x4″, or (in a few cases) four inches wide and of greater length determined by the particular figure.

In the discussion accompanying each figure are brought out all of the practical points that concern the execution of the symbol or symbols shown in the figure. Tracing and transfer paper may be used for the reproduction of the lay-out of the

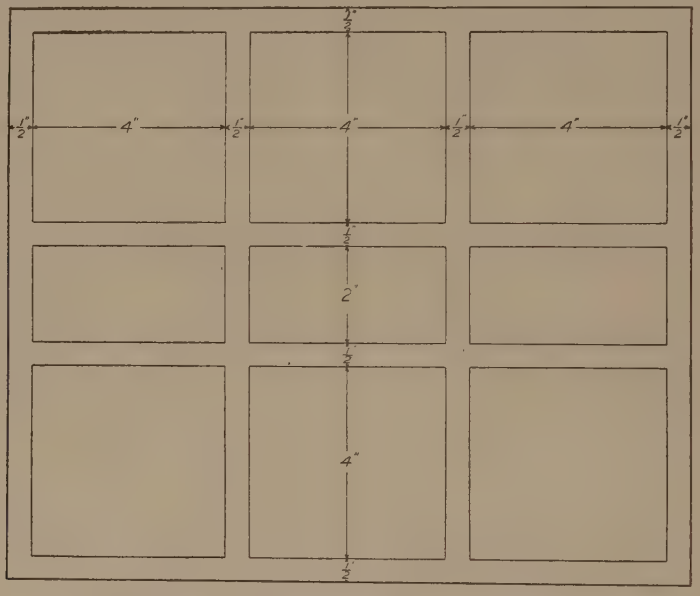

Fig. 8.—Form for practice sheet of conventional signs.

figure on the formal practice sheet. The figure should not be used to *copy* the arrangement of the vegetation symbols, but merely for comparison in this particular. The student should work out independently the arrangement of the vegetation symbols, and then compare his results with the figure.

All conventional signs for vegetation are to be applied to actual topography on the formal practice sheet. The topographical ground-work of each figure should therefore be transferred to the practice sheet or copied approximately by eye, and there executed in ink before the conventional signs are executed.

A lay-out for a formal practice sheet of conventional signs is shown in Fig. 8.

The border of the sheet is a rectangle 12″x14″, subdivided as shown. The spaces between the subdivisions and between them and the border are one-half inch.

The upper and lower rows each consist of three 4-inch squares, suitable for drawing the conventional signs for artificial and natural features. The vertical dimensions of these subdivisions and of the containing rectangle may be varied to accommodate the particular figures selected for reproduction in these spaces.

The middle row consists of three rectangles each 2″x4″, which may be subdivided into 2-inch squares. These are intended for the reproduction of the vegetation symbols, omitting that part of each figure showing the enlarged symbols and variations of form.

Two such formal practice sheets will cover a total of six vegetation symbols and twelve symbols representing artificial and natural features. Such a range of subjects will include all the conventional signs that would ordinarily be required for use in any one locality, and would therefore, in connection with the informal practice sheets, satisfy the requirements of practice.

The symbols for practice should be selected from among those given in Chapters VIII, IX, X and XI. The corresponding figures in the text should be examined and the accompanying discussion read carefully. Then such practice as may be necessary is done on the informal sheet in pencil and in ink, followed by finished execution in the appropriate color on the formal practice sheet. As before mentioned, work on these practice sheets of conventional signs should alternate with work in lettering, in order to lend variety and interest to the practice.

Mastery of topographical drawing such as will be gained by the practice outlined will prepare the student for work on any scale ordinarily used in survey work and in map drawing. For scales larger than six-inch, a somewhat coarser texture is used as a means of saving time, but the increase in size of symbols and the increase of spacing will be relatively small, and all the other general principles laid down are applicable to all scales. It is to be remembered that where large scales permit drawing to actual scale dimension, this is always to be done instead of adhering to a conventional size for any conventional sign.

CHAPTER VII

Lettering

It has been assumed that the student who desires to take up topographical drawing has already had a course in mechanical drawing. Any such course will have included also instruction in lettering, but the practice in teaching lettering is more and more to restrict the instruction to a single alphabet and that the simplest possible. Thus the assumption of previous instruction in mechanical drawing would include instruction in some "single-stroke" alphabet, usually the Reinhardt (Gothic) alphabet or some slight modification of it. This alphabet is very well set forth in Reinhardt's "Lettering for Engineers."

Good lettering in the Reinhardt system, vertical and slant, will answer every requirement of the topographer in field draughting, the size of the lettering being adapted to the space available and to the importance of the name to be recorded. The rules of all-capitals and lower-case-with-capital-initials given below should be observed.

The topographical draughtsman will, however, find it necessary to go into the subject of lettering much more extensively. Lettering on topographical maps is controlled by convention, which dictates that certain names shall be recorded in capitals, the size of the letters varying with the importance of the feature; that certain other names shall be recorded in lower case letters with capital initials, the size again varying with the importance of the feature; and finally, that different classes of information shall be recorded in different alphabets. These conventions impose on the topographical draughtsman the necessity of acquiring a knowledge of several different alphabets, and the ability to execute them according to a high standard of excellence. But the use of these several alphabets contributes toward clearness in the recorded data, and hence is to be commended. It is therefore recommended that the practice necessary to acquire facility in these different styles of lettering be undertaken, realizing that there is much lettering to be done on a topographical drawing, and

a high standard of drawing requires an equally high standard of lettering for the desired beauty of finish of the map as a whole.

The adopted conventions in lettering are as follows.

Civil Divisions.

The names of civil divisions are lettered in black in the Roman alphabet, Fig. 9.

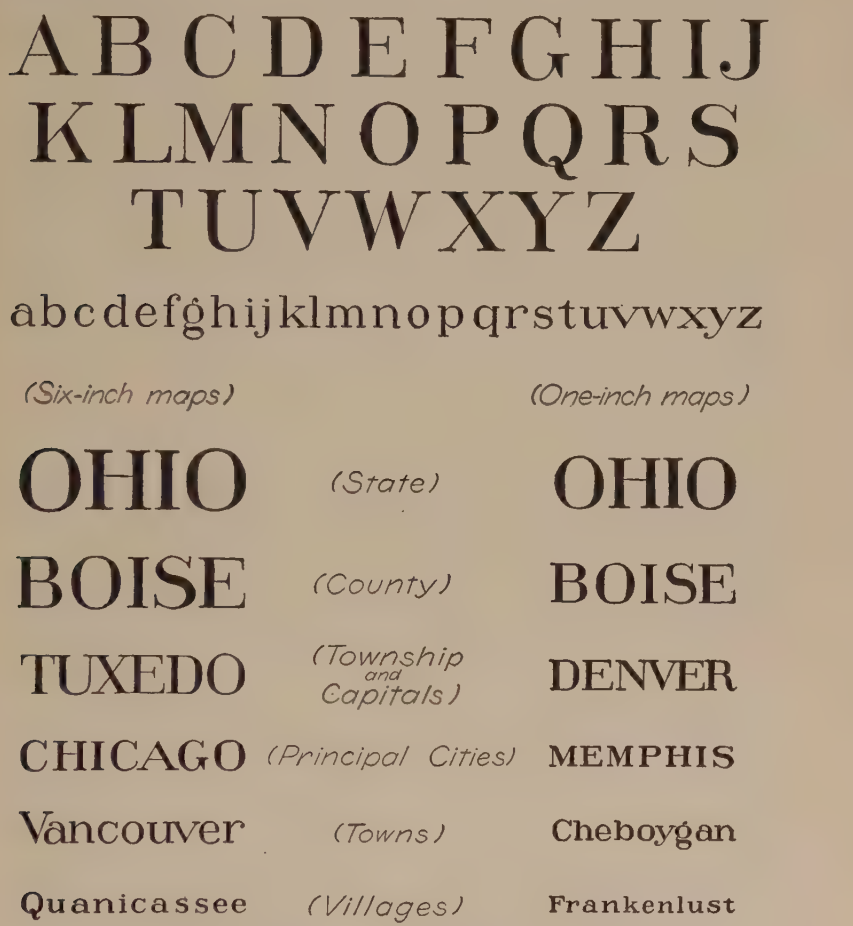

FIG. 9.—Roman alphabet. For names of civil divisions. *Conventional color black.*

The names of states, counties, townships, capitals, and principal cities are lettered in capitals, the size of the lettering varying with the importance of the name and with the scale of the map.

The largest size letters used for recording the above data on six-inch and larger scale maps* should be $\frac{3}{10}$ inch in height, scaling down in the order of importance of the names to a minimum height of $\frac{4}{30}$ inch for the smallest letters used in recording data of this class.

The names of towns and villages are lettered in lower case with capital initials. The more important towns have capital initials $\frac{4}{30}$ inch high and lower case letters $\frac{1}{10}$ inch high. Villages have capital initials $\frac{1}{10}$ inch in height and lower case letters $\frac{2}{30}$ inch in height. The width of the strokes in lettering diminishes with the height of the letter.

For one-inch and smaller scale maps, the maximum and minimum heights of letters for states, counties, townships, capitals, and principal cities should be $\frac{10}{40}$ inch and $\frac{1}{10}$ inch respectively. On these scales, the names of towns are lettered with capital initials $\frac{1}{10}$ inch high and lower case letters $\frac{2}{30}$ inch. The names of villages are lettered with capital initials $\frac{2}{30}$ inch high and lower case letters $\frac{1}{20}$ inch, the latter being the minimum size consistent with the rule of easy legibility.

Examples of lettering for the various civil divisions, in sizes appropriate for use on six-inch and one-inch maps, are shown in Fig. 9.

In lettering the names of civil divisions, it will usually be possible to letter on lines parallel to the bottom edge of the map. The name of a state, county, or township should be located in the center of the area represented, the spacing of the lettering being varied and widely extended if necessary to spread the name well over the width or length of the area. If the shape of the area is irregular, it may be necessary to letter the name obliquely or on a curve, but this will be the exception and should not be resorted to unless necessary. As a general rule, *all lettering should be so placed as to be read from the bottom or from the right-hand margin of the map.*

Names of cities, towns, and villages should always be lettered on lines parallel to the bottom edge of the map unless there is in-

* War game maps, used in the military service for tactical and strategical instruction, are made on very large scales (twelve inches to one mile). The lettering on these maps is a special case, as names and contour numbers must be readable at a distance of several feet. The lettering on these maps is double the size indicated for six-inch maps.

terference with some other name or feature, in which case they may be lettered obliquely, but still in a straight line. The name of a city, town or village may be located anywhere so long as the name refers unmistakably to the correct place. The preferable positions are to the right, to the left, centrally below, and centrally above, in order. That position should be selected for lettering the name which will interfere least with the other data to be recorded on the map.

Hydrography.

Names referring to hydrographic features of a map are lettered in black in Roman italics. See Fig. 10.

The names of oceans, sounds, large lakes, rivers, and bays are lettered in capitals, the size of the lettering varying with the importance of the feature.

The names of creeks, brooks, springs, small lakes, ponds, marshes, and glaciers are lettered in lower case with capital initials. The maximum and minimum sizes of lettering on maps of different scales are the same as for civil divisions.

Examples of lettering for the names of hydrographic features, in sizes appropriate for use on six-inch and one-inch maps, are shown in Fig. 10. Although the figure shows generally the appropriate size of lettering for the various features, the draughtsman must be guided in the selection of the size of lettering by the importance of the particular feature, for all these features vary much in importance even in the same class. Thus one river may be an important stream and another, although still called a river, may be of minor importance.

In lettering the names of hydrographic features, the irregularities in the outlines of bodies of water and in the courses of streams make it necessary as a general rule to letter their names in all sorts of directions and on all sorts of curves and sinuous lines. The ingenuity of the draughtsman will be severely taxed to select the location of hydrographic names so as to secure a satisfactory result.

The names of oceans, bays, sounds, and lakes are lettered within the water areas if there is the necessary room to do so. Even if it is necessary to use a smaller size of lettering than normally attaches to the importance of the feature, it is preferable to reduce the size of lettering somewhat if thereby the

name can be lettered within the water area. If only a small area of a large body of water appears on the sheet, the name may be omitted if the same body of water appears on an adjacent sheet and its name is given thereon. If the map is complete in a

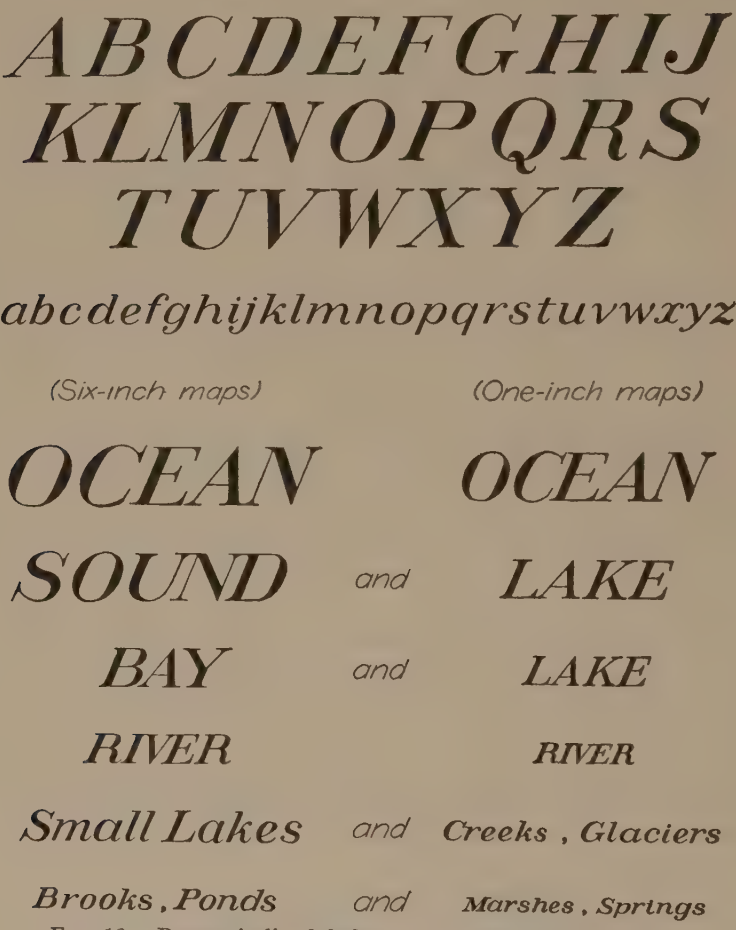

FIG. 10.—Roman italic alphabet. For hydrographic names. *Conventional color black.*

single sheet, the name may be allowed to extend out on the margin of the map beyond the border. In these difficult cases, the draughtsman should experiment in pencil layout to secure the best arrangement possible.

The names of lakes should be lettered within the water area if there is sufficient space, the direction of the lettering being accommodated to the shape of the lake. If there is not sufficient room to letter the name entirely within the boundary of the lake, it is preferable to place the name entirely outside the limits rather than partly within and extending out beyond the margin of the lake.

If lettered outside, the lettering is parallel to the bottom of the sheet and placed to the right or left, below or above, as in the case of the names of cities and towns.

The lettering of the names of streams offers the greatest difficulty. The lettering must follow the course of the stream, which may be tortuous; the lettering must also in general be quite widely spaced so as to extend for a considerable distance along the stream; and finally, the name must be readable from the bottom or right hand margin of the map. Sometimes all of these conditions cannot be fulfilled. In this case, it is best to diminish the spacing of the lettering and letter the name twice at two well-separated points.

If the stream is of sufficient width, the name is lettered in the body of the stream; if not, along the banks and generally parallel to the course of the stream. The sinuous courses of streams offer many problems in the arrangement of lettering. It is best to sketch curved guide lines free-hand, generally parallel to the stream but neglecting the smaller sinuosities. The slant of the lettering is with reference to a normal to the curve at the point where the letter is to be made. These normals should be drawn in lightly free-hand. If the letters are widely separated, guide lines are sketched in independently for each letter and the height tested. The lettering should not be too close to the margin of the stream. A good rule to follow is to keep a clear space equal to at least half the height of the lettering used.

Hypsography.

Names relating to hypsographic features are lettered in black in the vertical Gothic alphabet, Fig. 11.

The names of mountains, plateaus, lines of cliffs, and canyons are lettered in capitals. These names are to be subordinated on the map to the names of civil divisions with which they overlap, and hence the size of lettering used is reduced. The largest

size lettering for the names of mountains, etc., on a six-inch map should be $\frac{10}{40}$ inch in height, and the smallest $\frac{5}{40}$ inch. On one-inch and smaller scale maps, the largest lettering should be $\frac{5}{40}$ inch in height, and the smallest $\frac{3}{30}$ inch.

The names of peaks, small valleys, small canyons, islands, and points are lettered in lower case with capital initials. The lettering for this class of data on six-inch and larger scales should

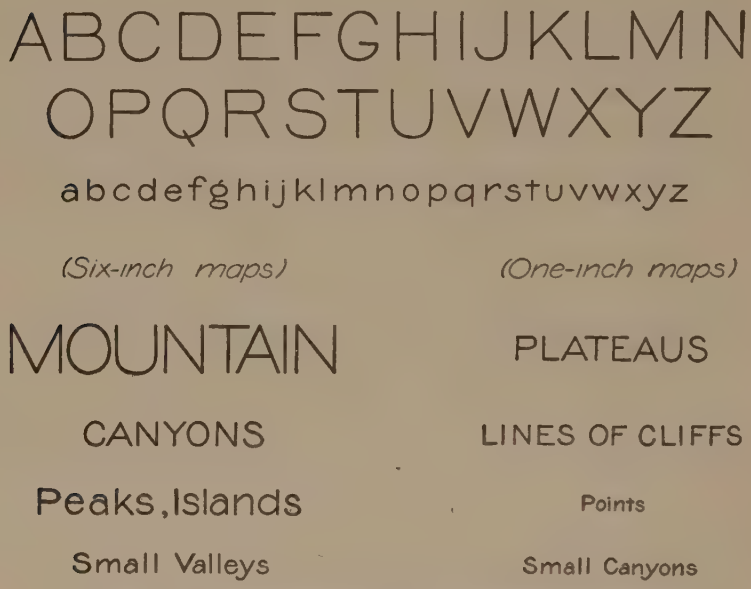

FIG. 11.—Gothic alphabet. For hypsographic names. *Conventional color black.*

vary between $\frac{5}{40}$ inch for the capital initials and $\frac{3}{30}$ inch for the lower case letters as a maximum, and $\frac{3}{30}$ inch for the capital initials and $\frac{2}{30}$ inch for the lower case letters as a minimum. The same features on one-inch and smaller scale maps should be lettered with capital initials $\frac{3}{40}$ inch in height and lower case letters $\frac{1}{20}$ inch. The variations in height are in all cases determined by the relative importance of the feature named.

Examples of lettering for the names of hypsographic features in sizes appropriate for use on six-inch and one-inch maps are shown in Fig. 11.

Public Works.

Names relating to public works are lettered in black in the Gothic italic alphabet, using capitals only. This alphabet is shown in Fig. 12.

The names of railroads, tunnels, bridges, ferries, wagon roads, trails, fords, and dams are lettered in Gothic italic capitals. On six-inch and larger scale maps, the lettering should be $\frac{1}{10}$ inch in height as a maximum, and $\frac{1}{20}$ inch as a minimum. The

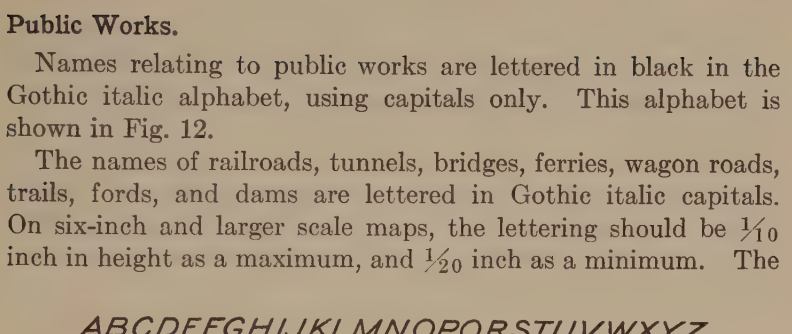

FIG. 12.—Gothic italic alphabet. For names of public works and for contour numbers.
Conventional color black, except contour numbers, which are brown.

features named are of relatively frequent occurrence and their importance is indicated by the symbol used to represent them rather than by the size of lettering. On one-inch and smaller scale maps, letters $\frac{1}{20}$ inch in height should be used entirely for these names.

Contour Numbers.

Contour numbers are figured in Gothic italic numerals, Fig. 12. If the map is drawn in colors, the contours are numbered in brown.

The standard height for contour numbers on six-inch maps is $\frac{2}{30}$ inch. For larger scales, this height should be increased to $\frac{1}{10}$ inch.

On one-inch and smaller scale maps, the numbers on the contours should be as small as possible and still remain legible, $\frac{1}{20}$ inch being about this lower limit of size.

Rules and suggestions for the numbering of contours on maps will be given under the discussion of contours in the use of conventional signs, Chapter IX.

Map Titles.

Maps offer a special case in the subject of titles. The title should include: a name which will identify the specific area represented by the map; the date of the survey; the methods by which the survey was made; the name of the surveyor or topographer; the name of the draughtsman; the name of the checker;

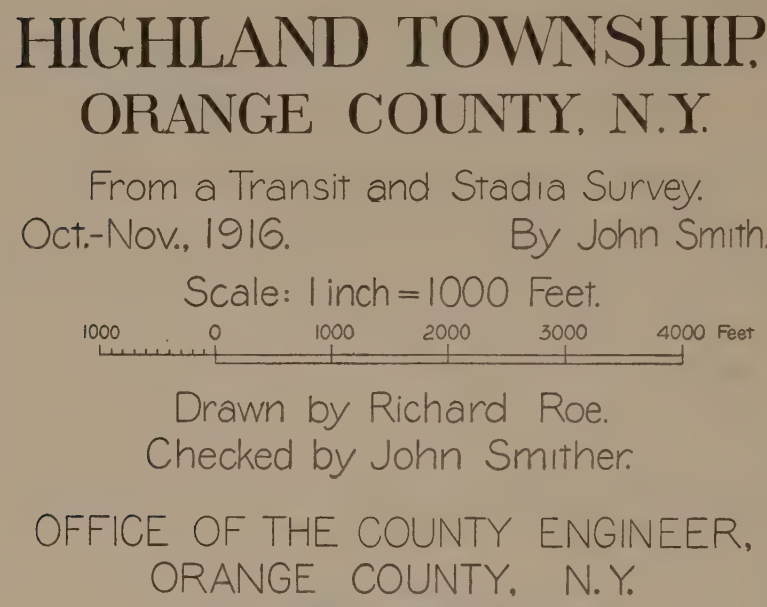
HIGHLAND TOWNSHIP.
ORANGE COUNTY, N.Y.
From a Transit and Stadia Survey.
Oct.-Nov., 1916. By John Smith.
Scale: 1 inch = 1000 Feet.
1000 0 1000 2000 3000 4000 Feet
Drawn by Richard Roe.
Checked by John Smither.
OFFICE OF THE COUNTY ENGINEER,
ORANGE COUNTY, N.Y.

FIG. 13.—Title for maps of small areas.
Conventional color black.

the scale of the map, preferably giving the scale by representative fraction and graphically; the identification of the connecting map sheets, if any; a line showing the direction of the true meridian; the contour interval and the datum, if contours are used; and the name of the office of issue.

In a small survey of an irregular area, there will usually be room for the title within the border of the map, the preferable position being in the lower right-hand corner. The title in such

cases should embody the above information and follow the usual rules for titles of drawings. The lettering should be done without any attempt at ornamentation, in the Roman or Gothic alphabets, or in a combination of the two. An example of such a title is shown in Fig. 13.

In the case of the map sheets of an extended survey, the separate sheets are bounded by latitude and longitude lines. Within the limiting lines of each separate sheet, the entire area is taken up by the map itself and there is no room for the form of title shown in Fig. 13. This condition has resulted in the adoption of the "split title," in which the various elements of the title are separated and entered at convenient points around the margin of the map. The form of lettering used in this case is the light-face Gothic, shown in Fig. 14.

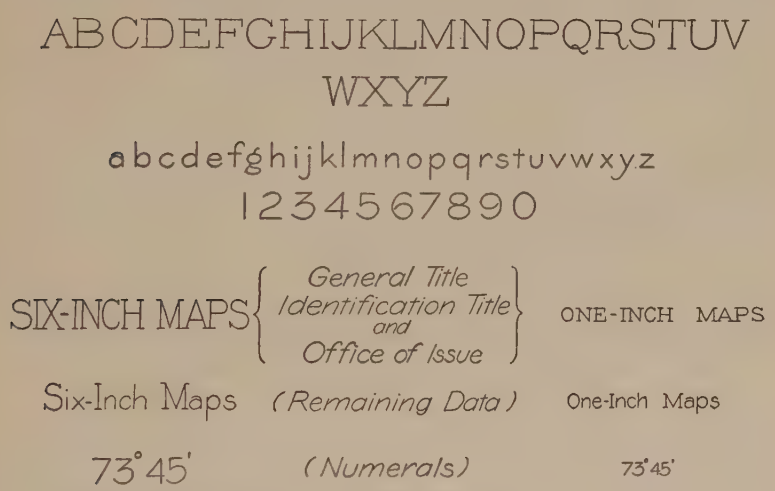

FIG. 14.—Light-face Gothic alphabet. For marginal lettering. *Conventional color black.*

In the split title, the purpose is not to distract the attention from the map itself by prominent lettering of the title. The identification title and the name of the office of issue should be in capital letters $\frac{3}{20}$ inch high for six-inch maps, and $\frac{3}{40}$ inch high for one-inch and smaller scale maps. The remaining information is lettered with capital initials $\frac{4}{30}$ inch high and lower case letters $\frac{2}{30}$ inch high on six-inch maps; on one-inch and smaller

scale maps, the capital initials are $\frac{3}{30}$ inch high and the lower case letters $\frac{1}{20}$ inch high.

The practice of the U. S. Geological Survey is to place the general title of the sheet at the center of the top margin, the name of the office of issue at the upper left-hand corner, the identification title in the upper right-hand corner, the data with reference to the survey, name of topographer, etc., in the lower left-hand corner, the date of publication in the lower right-hand corner, and the scale, datum, and contour interval in the lower margin at the center. The meridian is indicated on the lower margin to the left of the scale, and a small outline showing the topographer responsible for each area is placed on the right of the scale. The names of adjoining sheets are lettered in parentheses in Roman italic lower case with capital initials at the centers of the four sides and at the four corners. (See Fig. 62.)

General Remarks.

It is beyond the scope of this text to go extensively into the subject of lettering. The alphabets shown are those which the topographical draughtsman must master. With the single-stroke methods of lettering the student is presumed to be familiar. If not, the analysis of the direction and order of strokes in the Gothic italic alphabet are shown in Fig. 15.

This analysis will form a sufficient guide for practice. This practice must be continued until the strokes can be made smoothly and uniformly. The form of the oval shown by the letter O must be given special attention, as all of the curved strokes in the alphabet depend upon this form.

Single-stroke lettering will answer many of the requirements of the topographer. This lettering should be done with a pen suited to the weight of stroke desired. In many cases, however, even in the execution of the Gothic alphabets, it will be desirable to use a fine pointed pen and outline the strokes so as to secure uniformity in width. Gillott's 303 or the crow-quill pen may be used for this purpose.

Roman lettering is first outlined in fine lines. To this outline are added the limiting lines of the shaded portions of the letter, also in fine lines. The shaded portions are then filled in. The stages in the execution of a letter are shown in Fig. 16.

All lettering should be done free-hand. It is a mistake to

combine mechanical and free-hand execution by inking the straight portions of the letters with a ruling pen. It is best, however, to use a triangle in making the straight lines in the pencil lay-out of the lettering, as it saves time and insures verticality or uniform slope.

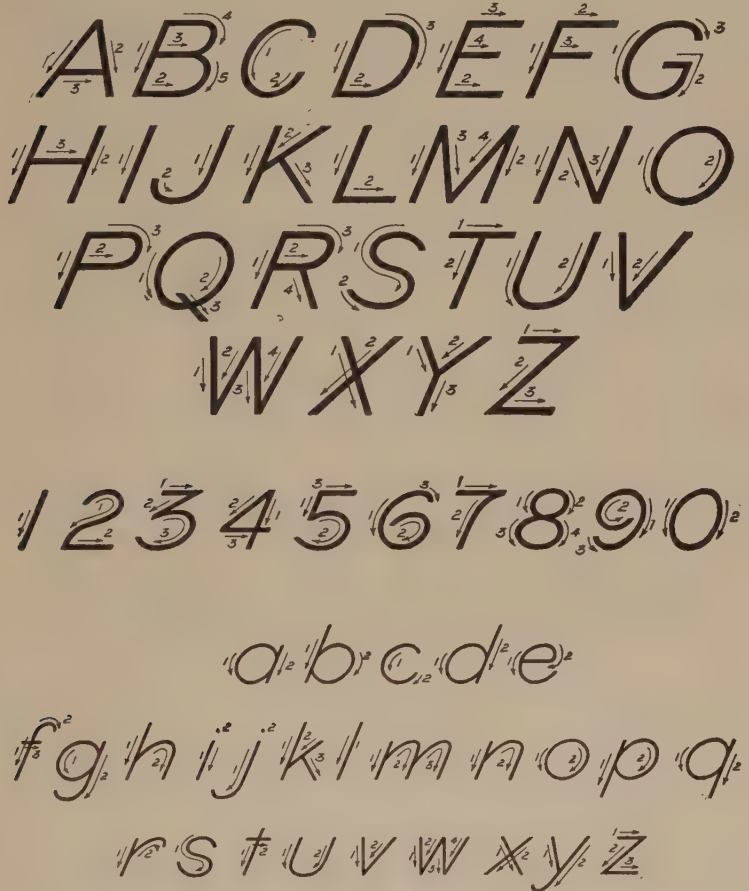

Fig. 15.—Analysis of strokes in Gothic italic alphabet.

Lettering is no better than its poorest element. Anyone who can execute the curves of letters well free-hand can also execute the straight strokes well. Ragged curves and mechanical straight strokes make a very poor combination, worse in general

effect than all free-hand work, which at least has the merit of uniformity of texture.

In lettering on tracing cloth, there is the additional difficulty of the buckling of the cloth. The cloth may be held in contact with the drawing board by weighting a triangle on it just above or just below the line of lettering, or the end of a penholder held in the left hand may be used for pressing down the tracing cloth.

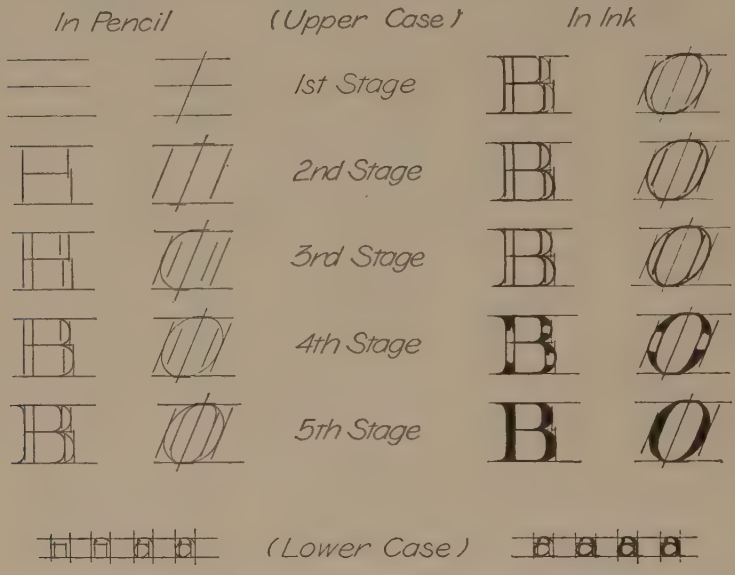

Fig. 16.—Stages in execution of Roman lettering.

The guide lines for lettering should always be drawn in pencil on the tracing cloth, as it is impossible to secure the best results by attempting to trace the lettering. As a general rule, it is better to use a fine pen in lettering on tracing cloth, outlining the letter and then filling in.

There is no escape from the fact that the topographical draughtsman must set for himself a high standard in lettering, and practice faithfully so that his proficiency in this respect shall be consistent with that in all other features of topographical drawing.

CHAPTER VIII

Conventional Signs

General Remarks.

The conventional signs adopted for the use of the map-making departments of the United States government have been published in War Department Document No. 418, which can be obtained from the U. S. Geological Survey Office, Washington, D. C. This pamphlet merely serves to establish standard forms of conventional signs, and there is no descriptive text to throw any light upon the many practical questions connected with the use of these conventional signs in topographical drawing. Both the draughting cost and the clearness of the finished map will depend in large measure upon the solution of these questions.*

The various symbols will be taken up in turn. Each symbol will be illustrated, and accompanying the figure will be a discussion of the execution of the symbol on topographic maps. All symbols will be shown in black in the figures following. The conventional color to be used in topographical drawing in color will be given in connection with the illustrative figures.

In the following pages, the abbreviated terms "six-inch map" and "one-inch map" will be used to refer respectively to maps of scale six inches to one mile (1 : 10,560) and one inch to one mile (1 : 63,360). For scales larger than six-inch, it is to be understood that the conventional symbols are to be made somewhat coarser in texture to lessen the draughting labor, though the symbols are not enlarged in proportion to the scale of the map.

In all large scale maps, symbols are drawn to scale if the scale dimension calls for a size larger than the type conventional symbol. The conventional signs for one-inch maps have been re-

* To illustrate, the symbol for *rice* hereafter shown was adopted to replace a former symbol much more difficult to execute. There were many square miles of rice land in the area to be surveyed in the Philippine Islands, and it was estimated that a saving of $600 could be made in the draughting cost of the work in contemplation by the adoption of a simpler symbol for the representation of this class of vegetation. The simpler symbol was accordingly adopted

duced to the minimum for easy legibility. For smaller scale maps the same dimensions of symbols are retained, and if the conventional symbol is inapplicable in the map area available, the information must be omitted. The amount of detail that can be shown legibly is thus determined by the scale of the map.

The conventional broken line on six-inch maps is made with $\frac{3}{20}$ inch dashes and $\frac{1}{20}$ inch spaces, and on one-inch maps with $\frac{3}{40}$ inch dashes and $\frac{1}{40}$ inch spaces.

A list of the standard abbreviations used in topographical drawing is given on page ix.

ARTIFICIAL FEATURES

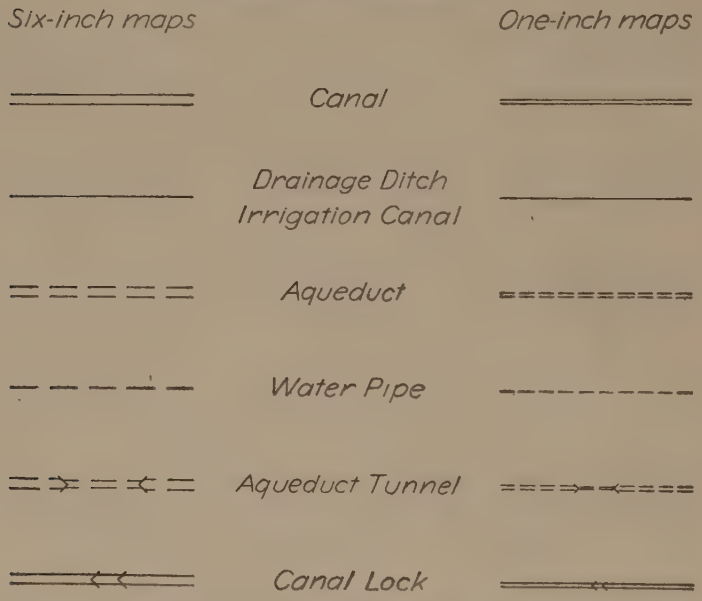

FIG. 17.—Canals, aqueducts, etc.
Conventional color blue, except tunnel entrances and canal locks, which are black. Fine lines.

Canal or Ditch.

If the symbols for these features are drawn in black, they must be identified by lettering the names at frequent intervals to distinguish them from the same symbols in black representing *roads*.

A navigable canal should be represented by the double line symbol. The conventional spacing is $\frac{1}{20}$ inch on six-inch maps

and $\frac{1}{50}$ inch on one-inch maps. If the actual scale width exceeds the widths given, the scale width should be used.

Drainage ditches and irrigation canals are shown by single lines for widths up to 20 feet on six-inch maps and 50 feet on one-inch maps. Beyond these widths, the conventions for canals should be followed.

Aqueduct or Water Pipe.

Aqueducts should be represented by a double broken line, conventional spacing $\frac{1}{20}$ inch for six-inch maps and $\frac{1}{50}$ inch for one-inch maps. If drawn in black, the name is lettered frequently to distinguish from the symbol for *poor or private road.* The dashes in the two lines are placed opposite each other instead of breaking joints.

A water pipe is represented by a single broken line, except for such large scale maps that the pipe diameter can be plotted to scale. "Water pipe" or "pipe line" is lettered to distinguish from the symbol for *trail* when drawn in black.

Aqueduct Tunnel.

The symbols at the tunnel entrances are two V's, representing the wing walls. If the aqueduct is drawn in black, the spacing between the two broken lines representing the aqueduct should be narrowed slightly through the tunnel to show a break from the regular convention, otherwise the symbol for the tunnel might escape attention.

Canal Locks.

The symbol for the canal lock is two V's, representing conventionally the gates of the lock, the two V's pointing up-stream. On six-inch maps, the V's should be spaced as determined by the scale length of the lock. On one-inch maps, the two V's are spaced $\frac{1}{20}$ inch apart, or as determined by the scale length of the lock.

Remarks.

Since all the features referred to are artificial, the alignment will be such as to permit the use of the ruling pen and guide for the execution of these symbols. The aqueduct tunnel entrance and canal lock symbols are executed free-hand.

Roads and Trails (Fig. 18).

The conventional width for a road on a six-inch map is $\frac{1}{20}$ inch, and on a one-inch map $\frac{1}{30}$ inch. These widths are such as to give reasonable prominence to the roads, since they are important features of maps. If the scale width of the road is greater than the conventional spacing, the scale width is used. For the use of fence symbols in connection with roads, see discussion under fences, page 66.

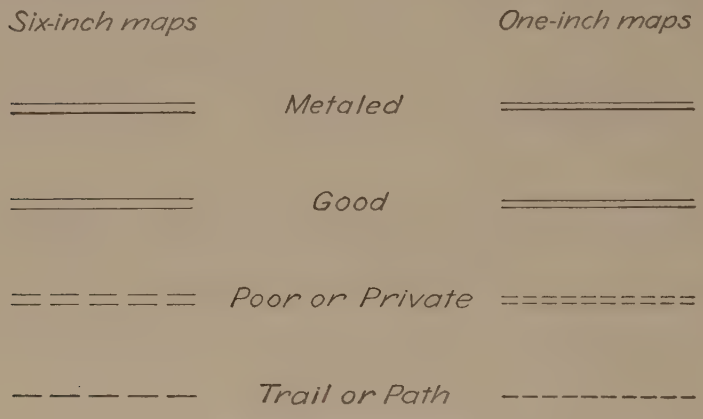

Fig. 18.—Roads and trails.
Conventional color black. Lines fine and medium, according to convention.

Uniform width of spacing of lines in road symbols is secured in the pencil work by specially preparing a double point pencil for drawing them. Two 6H pencils are prepared by removing the wood until the lead is bared along one side throughout the length of the pencil. The leads are now sharpened to narrow chisel points parallel to the flattened sides of the pencils, and the two pencils placed flat sides together and secured in place by rubber bands near the two ends. A small wedge is used near the lower rubber band to adjust the distance between the pencil points to the exact width desired. Thus adjusted, the two pencils will draw two lines with a uniform spacing whether used in connection with a straight-edge or irregular curve. Around sharp bends in the roads, the lines are sketched in lightly free-hand with a 6H pencil sharpened to a conical point. Thus it is assured that the symbols for the roads shall be of uniform width in the pencil drawing.

To draw the roads in ink, the railroad pen may be used, but many difficulties will be encountered. If the handle is slanted slightly, one point will leave the paper and there will result a defect difficult to repair. Smooth junctions of lines are difficult enough to make with a drawing pen, and much more difficult with a railroad pen. The draughtsman will therefore find it generally more satisfactory to draw the roads with a ruling pen.

Straight portions of the road are ruled in with triangles, using parallel motion. Curves are drawn in where the curvature is sufficiently large by means of the irregular curve, adjusting for parallelism by eye. Sometimes the road is drawn as a series of straight lines without rounding the corners, following exactly the lines of the traverse by which the road was located. The road itself is actually eased by curves at points of change of direction, and in general it should be so shown on large scale maps. The small arcs at the corners should be put in carefully free-hand with a fine pen.

In drawing the symbol for metaled roads, two pens should be used, set for the different weights of line required, and left unchanged in their setting until the work is completed. This obviates any difficulty in matching the weight of line.

In drawing the symbol for poor or private roads, the dashes of the two lines should be drawn so as to be in pairs opposite each other. With the railroad pen and in engraving, it is impossible to execute them otherwise. The appearance is much better than if the dashes break joints.

If the road is so sinuous that only short portions of it here and there can be drawn with the triangle or irregular curve, it is better to draw it all free-hand and thus secure uniformity of appearance.

On maps of scales smaller than one-inch, roads may be represented by single fine lines. It will be necessary on these scales to generalize the location of the roads and omit all the smaller sinuosities. For scales smaller than one-half inch to one mile, it is best not to attempt to show the entire road system. The result would be a net-work of lines without any real value, as these lines show no details of the roads and merely represent the fact that there is in general a road connecting each town or village with its neighboring towns and villages, a fact which may be assumed. It is better, on scales smaller than one-inch, to

abandon the idea of representing all the roads, and merely to show the principal ones, particularly the state roads and other metaled roads.

Steam and Electric Railroads (Fig. 19).

Railroads are an important feature of any map, and especially of military maps. They should stand out distinctly above the ordinary wagon road, and hence are drawn in medium or heavier lines. The lines representing double track railroads should be drawn somewhat lighter in weight than the line representing a

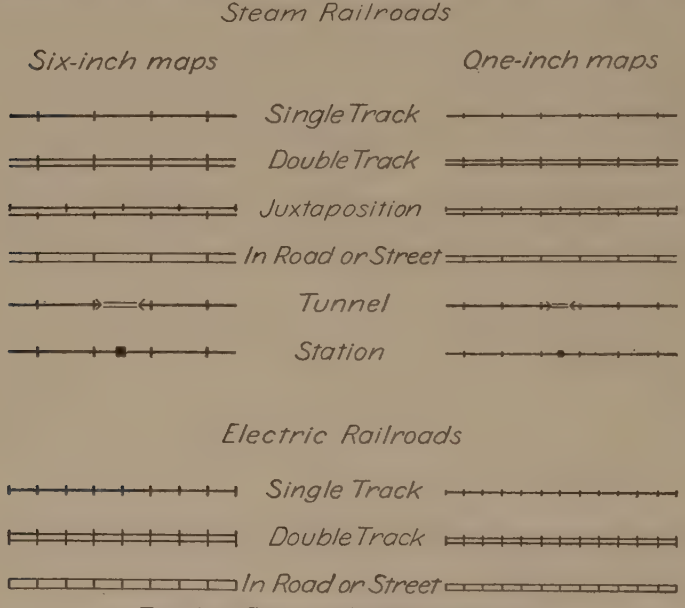

FIG. 19.—Steam and electric railroads.
Conventional color black. Lines, medium for one-inch maps, and increasing slightly in weight with increase in scale of the map.

single track railroad on the same scale. A double track railroad is not twice as important as a single track railroad.

On six-inch maps, the two lines of a double track railroad are spaced $\frac{1}{20}$ inch apart; on one-inch maps, they are spaced $\frac{1}{40}$ inch.

Since a railroad is laid out in tangents and easy curves, its alignment on the map will be such as to permit drawing with the ruling pen, using the straight edge and irregular or railroad

curves. The railroad pen may be used to advantage in drawing double track railroads, though equally good results can ordinarily be secured with the ruling pen.

The drawing of the line representing the railroad itself requires no special comment, other than that it is desirable to draw the line continuously in one direction rather than to draw the curved portions first and the straight portions afterward, as better tangencies can thus be secured.

Much of the drudgery of drawing the symbol for a railroad lies in drawing the cross lines representing the ties. These must be drawn accurately perpendicular to the track line and of equal length on both sides of it. The closer the spacing of the symbols the greater the number to be drawn, and the more objectionable is any irregularity. Economy in draughting time therefore calls for the widest spacing of the tie symbols consistent with clearness and good appearance. A good standard for spacing the tie symbols is $\frac{3}{10}$ inch for six-inch maps, and $\frac{3}{10}$ inch for one-inch maps. This spacing is halved for electric railroads.

If these distances be used, it will be found that the tie symbols can be drawn free-hand with sufficient regularity to satisfy the eye and with great gain in speed. The tie spacing should be marked off from the scale in pencil free-hand. The ties may be drawn with a single stroke of a coarse pen, or with a double stroke using a fine pen. If the map can be shifted about, it is preferable to draw all of the tie ends on one side of the track line, starting at the outer end of the tie and drawing toward the track line. This will give good square ends to the tie symbols. The other ends are then drawn from the opposite side in the same manner, taking care to align with the half symbols already drawn.

Where a railroad branches, it is best to carry a uniform spacing of the tie symbols on the main line, and start the tie symbols on the branch line breaking joints with those on the main line.

In other respects, Fig. 19 indicates the execution of the symbols sufficiently.

Telegraph and Power Lines (Fig. 20).

The use of the various symbols is sufficiently indicated by Fig. 20. The T's of the general symbol are $\frac{3}{40}$ inch in height on six-inch maps, and $\frac{1}{20}$ inch on one-inch maps. The cross line of the T is about two-thirds the length of the stem.

In the modified symbols along roads and trails, the stems are of the same length as in the general symbol.

The amount of labor involved in making the telegraph line symbols is reduced and the work greatly facilitated by spacing the symbols as widely apart as is consistent with satisfactory representation. The distance between symbols should be $\frac{3}{10}$ inch on six-inch maps, and $\frac{2}{10}$ inch on one-inch maps. These spaces are marked off with the scale. The telegraph symbol should as a rule be drawn free-hand, as the time consumed in drawing the symbols mechanically will more than counterbalance the gain in

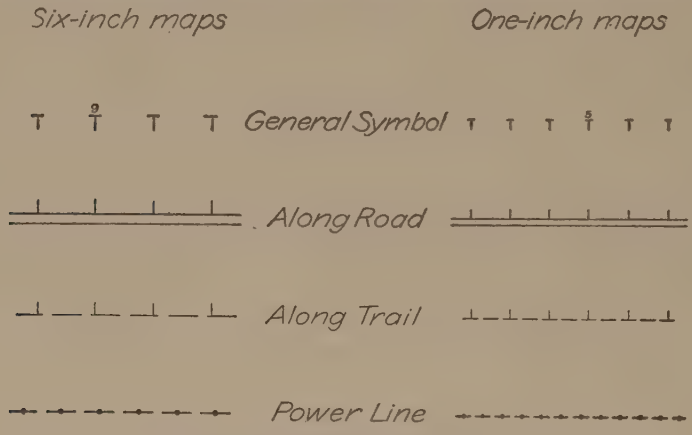

Fig. 20.—Telegraph and power lines.
Conventional color black. Fine lines.

quality of execution. This is more particularly true where the telegraph lines follow sinuous roads. Where the roads are generally straight, as is the case in many of the western states, mechanical execution of the symbols will be advantageous.

The question is bound to arise whether to draw the symbol for telegraph lines at all on one-inch and smaller scale maps. In most places in the United States there are telegraph and telephone lines along practically every road. To draw the symbol along every road involves the expenditure of a large amount of time, and the symbols occupy space needed for the representation of other information. Furthermore, the multiplicity of symbols conveys no more information than a marginal note to the effect that there are as a rule telegraph or telephone lines along all roads.

On six-inch and larger scale maps, telegraph lines should be

shown. On military maps, the number of wires on the line should be indicated occasionally in small figures, as shown in Fig. 20.

Bridges (Fig. 21).

The conventional representation of the various classes of bridges is shown for six-inch and one-inch scales. In each case, the stream represented is one hundred yards wide. The symbols are self-explanatory.

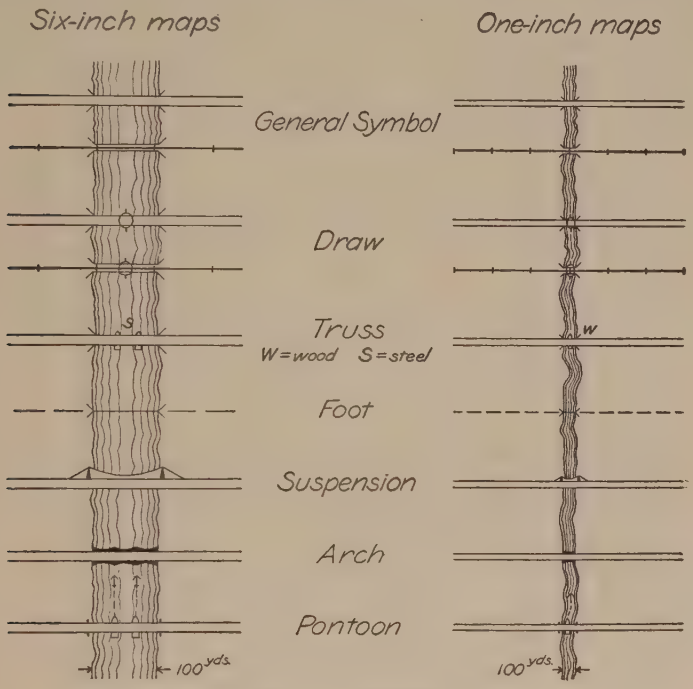

Fig. 21.—Bridges.
Conventional color black. Fine lines except for arch bridges.

The wing wall symbols at the abutments should be drawn free-hand as a means of saving time. They are drawn at an angle of 45° with the line of the axis of the bridge.

It will be seen by an examination of Fig. 21 that these symbols are generally applicable on six-inch maps. The only symbols that require any considerable space to draw them legibly are those for draw bridges and pontoon bridges, and in general these would be found only upon the wider rivers. On a narrow river,

there would be no mid-stream piers, and a truss bridge would be indicated by the letter *S* (=steel) or *W* (=wood) adjacent to the abutment.

On the one-inch scale, the space is very much crowded for drawing any but the general symbol on a stream one hundred yards wide. The inference is plain that a one-inch map is of too small a scale to admit recording any detailed information concerning bridges except the very important ones over the largest streams. If such detailed information is desired to be added in respect to the smaller bridges, as is the case for military purposes, the bridges are marked by reference numbers and descriptions are entered by marginal notes.

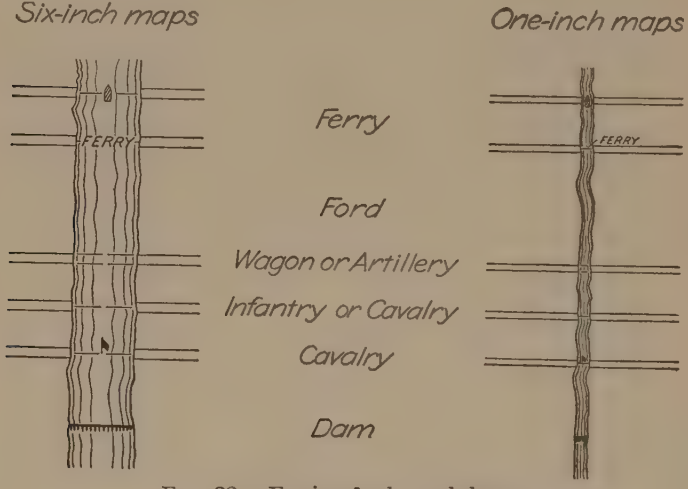

Fig. 22.—Ferries, fords, and dams.
Conventional color black. Fine lines except in symbol for dam.

Ferries, Fords, and Dams (Fig. 22).

The execution of these symbols requires no special comment. It is to be noted again that the symbol is much cramped on one-inch maps in streams one hundred yards wide, and it becomes impracticable to execute the symbols in narrower streams. Detailed information relative to the stream crossings can be given on one-inch maps only for the larger streams. Information relative to the minor crossings may be added by reference numbers and marginal notes, as in the case of bridges.

Buildings, etc. (Fig. 23).

The conventional symbol for an isolated house is a solid black square, $\frac{1}{20}$ inch on six-inch maps and $\frac{1}{30}$ inch on one-inch maps. These conventional symbols correspond to buildings 44 feet square on six-inch maps, and 176 feet square on one-inch maps.

On a six-inch map, the conventional symbol represents the average farm-house approximately to scale, and in general all buildings can be represented on this scale in their correct relation to each other. All large buildings can be represented correctly in plan if it is desired to do so, but it is unusual in topographical surveys of extended areas to take the data in such detail. There

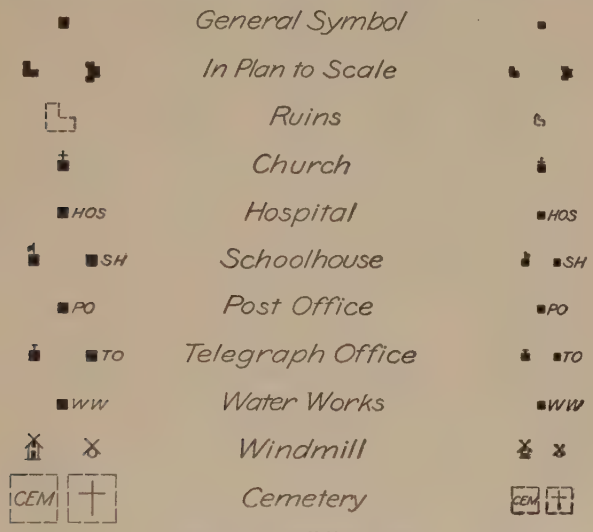

Fig. 23.—Buildings, etc.
Conventional color black. Symbols as shown.

will be little call, therefore, for the topographical draughtsman to represent buildings otherwise than by the conventional symbol, except on maps of larger than six-inch scale.

On one-inch maps, the conventional symbol for a building is a gross exaggeration in scale of the actual dimensions of all ordinary buildings. Where houses are close together, it will be impossible to show all the houses on account of the scale dimensions of the symbol. An individual symbol therefore represents an isolated house, but a line of house symbols along a road or street represents a line of houses, not necessarily the same number of

houses that there are symbols. In this case, the scale length of the line of symbols should show the ground distance between the end houses on the line.

Fig. 24.—Cities, towns, and villages.
Conventional color black. Symbols as shown.

The symbols are self-explanatory. The abbreviations for hospital, post office, etc., are from the list of standard abbreviations given on page ix.

Large buildings are drawn with the ruling pen. The conventional symbol is drawn free-hand with a fine pen, being first outlined and then filled in solid. Care should be exercised to make the symbol accurately square and with square corners.

Cities, Towns, and Villages (Fig. 24).

Cities, towns, and villages are merely combinations of the road and building symbols, heretofore discussed. In cities and towns, where the blocks are built up solid, a continuous line is

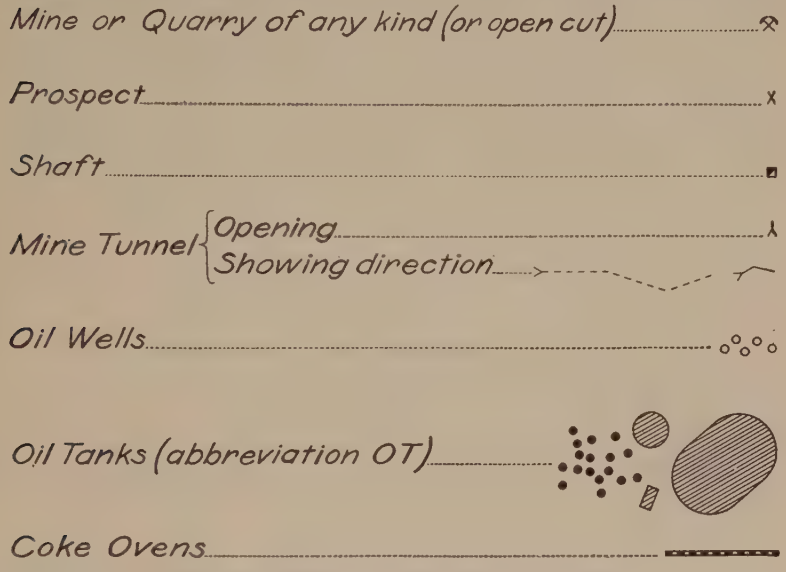

Fig. 25.—Mines, oil wells, and coke ovens.
Conventional color black. Lines as shown.

used instead of individual building symbols. This symbol is $\frac{1}{20}$ inch wide on six-inch maps, and $\frac{1}{30}$ inch on one-inch maps.

Again the difficulty of representing the details of street plan and buildings in the restricted area of a one-inch map becomes apparent. In civil maps, where the cities, towns, and villages are important, the plan is shown in as much detail as possible. The size of the house symbol may be reduced for this purpose.

In military maps, the actual street plan is not so important and the representation of cities, towns, and villages may be generalized as shown in the figure. Such generalization becomes necessary on maps smaller than one inch. On small scale geographic maps, the symbols shown at the bottom of Fig. 24 are used.

For lettering the names of cities, towns and villages, see Fig. 9.

Mines, Oil Wells, and Coke Ovens (Fig. 25).

The execution of the symbols shown in Fig. 25 is mechanical, and requires no special comment. The symbols shown, except

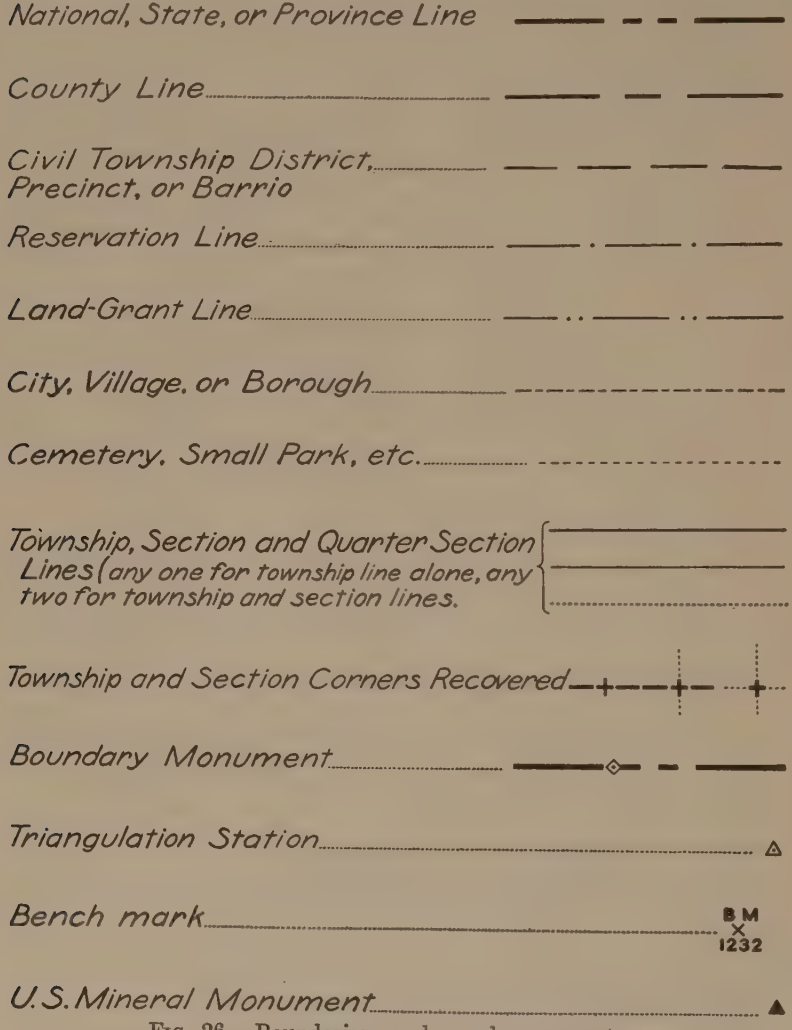
National, State, or Province Line
County Line
Civil Township District, Precinct, or Barrio
Reservation Line
Land-Grant Line
City, Village, or Borough
Cemetery, Small Park, etc.
Township, Section and Quarter Section Lines (any one for township line alone, any two for township and section lines.
Township and Section Corners Recovered
Boundary Monument
Triangulation Station
Bench mark
BM
1232
U.S. Mineral Monument

Fig. 26.—Boundaries, marks, and monuments.
Conventional color black. Lines as shown.

that for oil tanks, are of size suitable for maps of all scales. The symbol for oil tanks on small scale maps should be the solid

black circles. The cross-hatched form is used for large scale maps, the symbol being executed in plan to scale. The cross-hatching should be spaced about $\frac{1}{40}$ inch, the spacing being done by eye.

Boundaries, Marks, and Monuments (Fig. 26).

The execution of these symbols is mechanical, and requires no special comment.

Fences (Fig. 27).

On account of the fact that fences are relatively unimportant features, the symbols are drawn in very fine lines to reduce their prominence on the map. On tracing cloth, the thinned black ink is used to bring them out on the blue-print in a blue tinge, thus subordinating the fences to the more important data on the map.

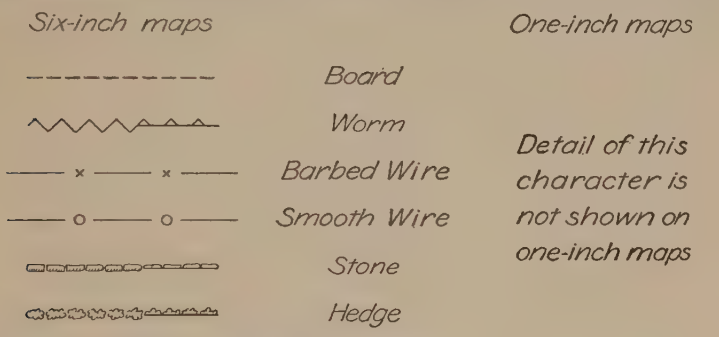

FIG. 27.—Fences.

Conventional color black, except hedge fence, which is green. Very fine lines.

The following remarks apply to the fence symbol on six-inch and larger scale maps. The same details are shown in finer texture down to two-inch scale. On one-inch and smaller scale maps, fence symbols should be omitted.

The symbol for a board fence, which may also be used as a general symbol for all kinds of fences, is a broken line with dashes $\frac{3}{40}$ inch and spaces $\frac{1}{40}$ inch in length, to distinguish from the broken line symbol for *trail*, and from *water pipe* when the latter is drawn in black.

The symbol for stone fence is drawn free-hand, in the style shown in the figure. The symbol for worm fence may be drawn free-hand or mechanically. In case it is drawn free-hand, in the pencil layout a series of parallel strokes are drawn $\frac{1}{10}$ inch apart at an angle of 45° with the line of the fence and longer than the

panel length. The intermediate panels perpendicular to the strokes first drawn are now put in and gauged carefully by eye so that the panel lengths will be equal, and the symbol symmetrically disposed about the center line of the fence. The symbol may be drawn mechanically with somewhat better results, but more time is required.

The symbols for barbed and smooth wire fences are as shown. A broken line is first drawn with dashes $\frac{3}{10}$ inch and spaces $\frac{3}{20}$ inch long. Within these spaces and accurately on the center line of the fence are drawn crosses for the barbed wire fence symbol, and circles for the smooth wire fence symbol. The crosses have bars $\frac{1}{20}$ inch in length. These bars must bisect each other accurately and be mutually perpendicular, making angles of 45° with the line of the fence. The crosses are drawn free-hand. In the smooth wire fence symbol, the circles are $\frac{1}{20}$ inch in diameter. They also are drawn free-hand. The methods described in Chapter V are particularly applicable to small symbols of this character.

If color is used, the hedge fence symbol is drawn in green. The symbol is a succession of small tree symbols, elongated in the direction of the line of the fence. The execution of this symbol will be more thoroughly understood by reference to the discussion of the symbol for trees, page 88.

As a general rule, roads are fenced in, hence the road symbol is complicated by the question of the fence symbol. It is desirable as a matter of economy both of time and space in drawing to superpose the fence symbols upon the lines which constitute the symbol for the road itself, but this cannot always be done. If the symbol for board fence be substituted for the lines of the road symbol, the distinction between metaled, good, and poor roads is destroyed. The same thing is true of the worm fence, the stone fence, and the hedge fence. In these cases, the symbol for the fence must be placed outside of the road symbol. The board fence symbol is drawn as close to the road symbol as possible, leaving a space of $\frac{1}{50}$ inch. To economize space in the cases of the worm, stone, and hedge fences, one-half of the symbol may be drawn against the line of the road symbol, as if the road line bisected the fence symbol and the inner half of the latter were removed. This method is indicated at the right-hand end of the fence symbols in Fig. 27.

In the cases of the barbed and smooth wire fences, which for-

tunately are of most frequent occurrence, the fence symbol is superposed directly upon the road symbol. This leaves the information clear respecting both the road and fences without requiring any additional space or lines. The road lines, fine or medium according to convention, are drawn with dashes and spaces as prescribed for the wire fence symbols. The spaces are left opposite each other so that the crosses and circles are in pairs and not staggered. The paired arrangement presents much the best appearance.

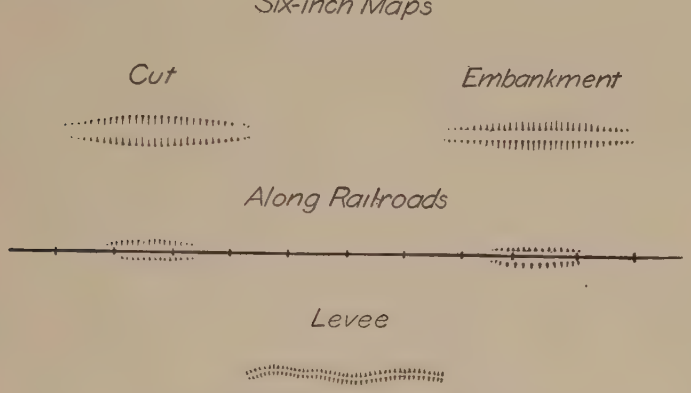

FIG. 28.—Cuts and embankments.
Conventional color brown. Lines as shown.

Cuts and Embankments (Fig. 28).

The general symbol for cuts and embankments consists of hachure lines. These lines are heavier at the top of the slope and diminish in width down the slope. They are margined at the top of the slope, and the edge of the cut or fill may be indicated by a broken line. The margining at the top and the manner of drawing the symbol indicate the direction of the slope and make a clear distinction between cuts and embankments.

Cuts and fills are shown in plan to scale. This prohibits the use of the symbols on one inch and smaller scale maps except in very unusual cases.

The symbol is a very laborious one to make, and it should be made as coarse in texture as is consistent with clearness and good appearance. The strokes should be drawn from the top of the slope toward the bottom. The symbol is executed freehand.

CHAPTER IX

Conventional Signs—Continued

NATURAL FEATURES

Maps of All Scales

Streams represented to scale width

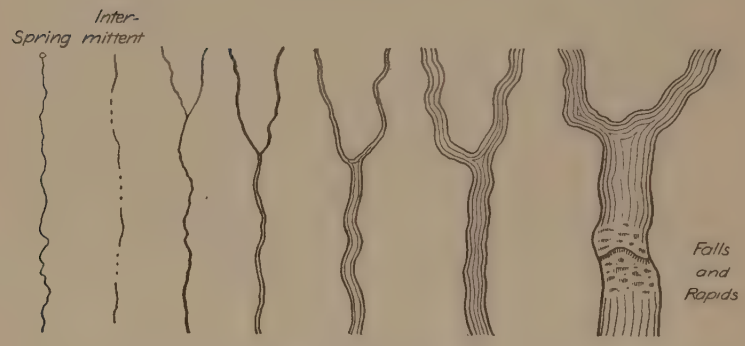

Fig. 29.—Streams.
Conventional color blue. Lines of various weights as shown.

Streams (Fig. 29)

When drawn in blue, the streams are executed in smooth sinuous lines; when drawn in black, a small tremor is forced (if necessary) so as to cause irregularity in the lines and thus make a conventional distinction between the lines representing streams and those representing contours.

The course of the stream is plotted according to the data furnished by the survey. Small streams are usually plotted by course and average width. For the larger streams, both shore lines may be located and plotted separately.

The representation of streams depends upon the scale width of the stream and not upon the scale of the map. The discussion may therefore disregard the scale of the map and concern itself only with the execution of the symbol in various widths.

The symbol for the spring is merely a small circle of a minimum diameter of $\frac{1}{40}$ inch. An intermittent stream is represented by a conventional broken and dotted line, in which the dashes are $\frac{2}{10}$ inch long and the dots are spaced $\frac{1}{20}$ inch apart.

The smallest stream of regular flow is represented by a single fine line. As the size of the stream increases, the weight of the line is increased until it reaches a medium line in weight. When a medium line no longer represents the full scale width of the stream, two fine lines are substituted. The space between the lines and the weight of the lines are increased as the stream widens. When the symbol to scale reaches an absolute width of $\frac{1}{10}$ inch, the two shore lines should be medium lines in weight.

When the stream symbol exceeds $\frac{1}{10}$ inch in width, two fine line waterlines are added, spaced about $\frac{1}{40}$ inch from the shore lines. Successive waterlines from the shore line outward toward mid-stream should be spaced $\frac{1}{40}$, $\frac{1}{30}$, $\frac{1}{20}$, and so on in gradually increasing distances. These waterlines are added in the stream symbol as the stream widens sufficiently to make room for them, and are so graded in weight that the outer waterline is a fine line, and those between it and the shore line increase in weight so that there is a uniform gradation.

When the stream symbol reaches one inch in width, there should be six waterlines parallel to each shore line. No greater number should be used, and in wider streams the center should be left blank.

The waterlines immediately adjacent to the shore line follow its sinuosities closely. The successive waterlines outward generalize these irregularities more and more until the outer waterlines in wide streams become a series of smooth curves with rounded junctions. Thinned ink may be used for the outer waterlines on tracing cloth, thus giving these lines a blue tinge on the blue print.

The waterlining may be considered to represent the wave action along the shore. It serves to accentuate the stream symbol for the wider streams and thus make them important features of the map as the streams are of the area represented.

The waterlining is not interrupted where the name of the stream is lettered within its water area if the map is drawn in color. In black, the waterlining is interrupted for the lettering.

A very effective substitute for waterlining may be produced on tracing cloth by the use of water colors. A thick wash of

burnt sienna is prepared. With little color in the brush, wavy lines are drawn on the dull side of the cloth, parallel to the shore line. The lines are spaced wider apart outward from the shore line, and at the same time the color is thinned or less of it is used. The burnt sienna has sufficient opacity to exclude part of the light in blue printing, and the effect on the blue print when the work has been properly done is very satisfactory. The method has the advantage of saving much time and labor as against waterlining with pen and ink.

On all maps in color, water features may be given a flat tint of Prussian blue instead of using waterlining.

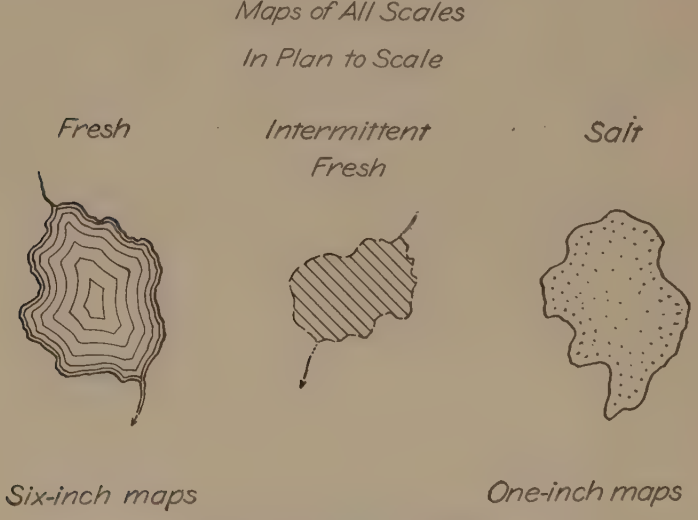

Fig. 30.—Lakes and ponds.
Conventional color blue. Lines of various weights as shown.

Lakes and Ponds (Fig. 30).

The shore line is drawn in plan to scale. For very small ponds, the shoreline is drawn as a fine line, and the weight of the line increases with the size of the body of water until, for a map area of about one square inch, the shore line is a medium line. Waterlines are added following the same rule as for streams, increasing the spacing and diminishing in weight outward from the shore line toward the center of the lake.

Instead of waterlining, a flat wash of Prussian blue may be used when the map is drawn in color.

In salt ponds, dots are used as a convention instead of waterlining. These dots should be comparatively widely spaced to save time and labor. The dots are coarser near the shore and become smaller and more widely spaced toward the center of the pond. The dots nearest the shore line are arranged parallel to the shore line and are regularly spaced, breaking up into an irregular arrangement with increased spacing toward the center. A broken shore line is used in both fresh and salt lakes and ponds to indicate an intermittent body of water. In intermittent fresh-water lakes and ponds, section-lining is substituted for waterlining, as the waterlining itself cannot well be drawn in broken lines. This section-lining should be in very fine lines, spaced $\frac{1}{20}$ inch on six-inch maps and $\frac{1}{30}$ inch on one-inch maps.

If the waterlining is in black, it is interrupted for the lettering of the name of the lake or pond. For this purpose, the name should of course be lettered first. It is then boxed in in pencil, leaving a narrow margin around the lettering. The waterlining is discontinued at the lines so drawn. If waterlined in blue, the waterlining may either be discontinued as just described, or drawn directly through the lettering.

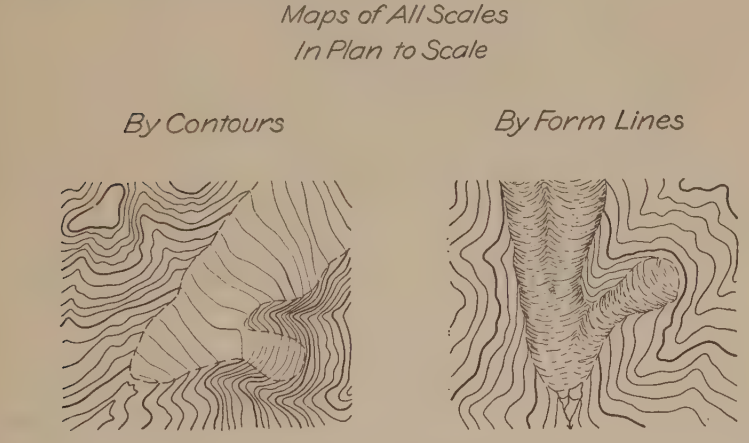

FIG. 31.—Glaciers.
Conventional color blue. Fine lines.

Glaciers (Fig. 31).

The outline of the glacier is drawn in plan to scale in a broken line. On a contoured map, the contours of the surface of the

glacier are drawn, and on a hachured map (see discussion of contours next following), the surface of the glacier is delineated by form lines.

When the map is drawn in color, both the outline of the glacier and its contours or form lines are drawn in blue, thus giving a clear and effective distinction between the glacier and the surrounding ground forms; but when drawn in black this distinction is lost, and the conventional sign is not at all a satisfactory representation. In this case, the name and the abrupt break in the form of the contours would have to be relied upon to make the representation clear.

Fortunately this is a class of data with which the topographical draughtsman will have to deal but infrequently, and the faults of the symbol need cause no grave concern.

Maps of All Scales

Fig. 32.—Contours.
Conventional color brown. Lines fine and medium.

Contours (Fig. 32).

Present practice has crystallized in the use of contours for the representation of ground forms, superseding the older method of representation by the use of hachuring.

Hachuring may therefore be dismissed with a very brief discussion. It has as its basis the representation of various slopes by means of strokes parallel to the direction that water would flow at the spot represented. The declivity of the slope is indicated by the weight and spacing of the hachure lines, the heaviest strokes and the closest spacing being used to represent the steepest slopes. It is thus a form of shading which gives a sort of pictorial representation of the ground forms by an interpretation in terms of light and shade. Similar in principle but easier

in application on drawing paper is the method of *stumping*, in which pencil dust is rubbed into the paper for the desired shading, and set by the application of water. A method similar in principle applicable on tracing cloth is to apply water color to the dull side of the tracing cloth in a manner entirely similar to that described under waterlining. Ragged brush lines, using burnt sienna for opacity, are drawn in the direction that contours would have. More color and closer spacing of the strokes are used where the slopes are steeper. The effect produced on the blue-print is a style of shading which gives the impression of relief, much the same in effect as is accomplished by hachuring. It is, however, not an attempt to represent the ground forms more than approximately, and the method is used only where the data is very imperfect, but still sufficient to locate the principal hill masses and represent their approximate forms. The color can be applied in the same way to the map sheet itself.

The defects of the method of hachuring are: the absence of accurate representation; the very high degree of skill demanded of the draughtsman; the immense amount of draughting time required; and the fact that on steep slopes the weight of the hachure shading almost precludes the representation of other information. The single counter-balancing advantage is that it is a quasi-pictorial form of representation which is intelligible to an untrained eye and to the unimaginative mind. But modern tendency is toward accurate representation by the simplest means, and the individual must familiarize himself with the conventional methods of representation and be prepared to interpret them.

As a principal means of representing ground forms, hachuring has been superseded by the more accurate and more economical method of representation by contours. Hachuring is still used occasionally as a supplement to contours in the representation of earth bluffs where the slopes are so steep that the contours would be so closely spaced as to tend to run together and be indistinguishable. (See Fig. 35.) But it should be remarked that where there is insufficient space to draw contours there is also insufficient space to use hachures.

The subject of the accurate delineation of ground forms by means of contours belongs in surveying, but both the topographer and the topographical draughtsman must understand the principles thoroughly. Otherwise the data secured by the topog-

rapher will be defective as a representation of the ground forms, and the draughtsman will fail to interpret faithfully in the execution of the map.

Interpretation of topography rests primarily upon a correct conception of the relation of geology to topographic type forms. A thorough understanding of this subject leads to a correct interpretation of the topographical features in their representation by contours.

In maps of very large scales, and by the same token usually of small areas, the contours may be run out and accurately located. In such cases neither the topographer nor the draughtsman has any responsibility other than to record the contours accurately as located, just as any other determined line of the map. But the great majority of topographical maps are on those smaller scales in which the contours are sketched in from a few locations within an area, and are more and more a generalization of the topographical forms as the scale of the map decreases. Yet this generalization must preserve the characteristic "expression" of the topography, which means a faithful and accurate, even though general, representation of the ground forms.

The full discussion of this subject is beyond the scope of this text, as it concerns the field work of a survey principally and the draughting work only incidentally.*

The topographical draughtsman is responsible, however, only for the faithful interpretation of the data secured in the field, and his art does not include any "improvements" upon the field work of the topographer. He must be prepared to interpret the field notes of a transit and stadia survey in the manner described in the text-books on surveying, but in general no satisfactory delineation of the ground forms can be made except by the man who makes the survey and backs his interpretation of the notes by a knowledge of the ground represented.

It will be sufficient for the purposes of this text to assume that the topographical draughtsman is in possession of a contoured

* The subject will be found very satisfactorily treated in Breed and Hosmer's "Surveying," Volume II (Higher Surveying), Chapter VII. John Wiley and Sons, New York. A number of comparative studies in map expression, showing the same areas well and poorly mapped, are given. The whole chapter is well worthy of study in connection with the subject of the representation of topographic forms by contours.

representation of the ground. It is then his business to transfer this data in whatever form furnished him, whether plane-table sheet or field sheet in other form, to the general map sheet, and there enter the data as part of the finished map.

If the data reaches the draughtsman on the proper scale and on thin paper, the transfer to the regular map sheet is accomplished by means of transfer paper. (See page 20.) If on thick paper, the data may first be traced on thin paper and transferred as before, but there will be a loss of accuracy in the double transfer. If the field sheets are on thick paper, or are on a larger scale than the finished map, as is very frequently the case, the transfer and reduction to the proper scale are made by the pantograph. By one or the other of these processes, the contours will be transferred in pencil to the map sheet. The problem is now to do the work in ink in clear and permanent form, and perhaps thereafter to make a tracing of the map.

So far as the contours themselves are concerned, they are merely continuous and sinuous lines, which satisfactory finish of the map requires to be inked in smooth lines of uniform weight, following exactly the lines determined by the pencil work. Clearness and easy reading of the map require that certain of the contours, usually every fifth one, shall be inked in a heavier line and thus stand out and facilitate general comparisons of elevation. (See Fig. 32.) Frequent reference to the absolute elevation being desirable in the study of a map, the elevations represented by the contours must be entered upon them at a sufficient number of places on the map sheet that any and all contours may be identified in absolute elevation without difficulty.

Since there is no direct way to tell whether a contour encloses an elevation or a depression, a special convention has been adopted to distinguish depression contours. (See Fig. 33.)

Maps of All Scales

FIG. 33.—Depression contours.
Conventional color brown. Lines as shown.

Where the slopes are steep and rocky, the conventional representation is as shown in Fig. 34.

In this representation, the contours are purposely made ragged and irregular in weight, and strokes are drawn at right angles to the contours to make an indication of a cliff.

For earth bluffs, and to represent the eroded banks of streams, hachuring is sometimes used in conjunction with contours, as shown in Fig. 35.

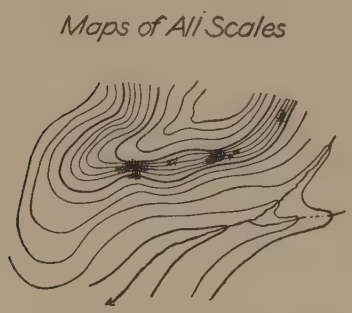

FIG. 34.—Rocky slopes.
Conventional color brown. Lines as shown.

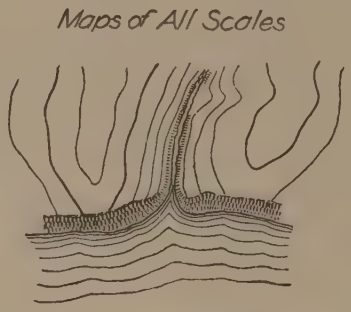

FIG. 35.—Earth bluffs and eroded stream banks.
Conventional color brown. Lines as shown.

The conventions of contour representation have been given above, and it remains to discuss the drawing of contours on maps. There are two distinct phases of the problem, (1) drawing the contour lines, and (2) numbering the contours.

Drawing the Contour Lines.

Beauty of finish of the map requires that the contours shall be drawn in smooth and uniform lines, intermediate contours in fine lines, and the accentuated contours in medium lines.

As a means of insuring smooth lines of uniform weight, the contour pen is used. The mechanical manipulation of this instrument has been described on page 15. Its defect lies in the lack of absolute control of the pen and the consequent inability to follow exactly the pencil lines of the contours.

With the ordinary pen free-hand it is possible to follow the pencil work exactly, but few can achieve with it the smoothness and uniformity of line possible with the contour pen.

Choice must be made between the ordinary pen and the contour pen as a means of drawing contours. It really is a choice between the last degree of finish and the last degree of accuracy.

This choice will depend greatly upon the texture of the topography to be drawn. Where the topographic forms are intricate and the slopes steep, so that each individual contour is complicated in its sinuosities and the difficulty is further aggravated by close spacing of the contours, it will be found necessary to use the ordinary pen and do the work free-hand. The point of the contour pen and the method of holding the pen combine to interfere with a clear view of the line to be followed, and the difficulty of making smooth junctions forces the drawing of lines sometimes in the most unfavorable direction.

In less intricate topography, where the contours are more widely spaced and less complicated, the contour pen will be found to be superior in both speed and finish to the ordinary pen, though still inferior in accuracy.

In drawing contours with the ordinary pen, they should all be drawn in the particular direction found to yield the smoothest and most uniform line, which will usually be found to be directly toward the body. A fine pointed pen is used for the fine line contours, and either a fine pen with pressure or a coarse pen may be used for the medium line contours. Or the medium line contours may be drawn with the contour pen and the fine line contours with the ordinary pen. In any case, the medium line contours should be drawn first and the fine line contours interpolated afterward.

In drawing the contours with an ordinary pen, it is best to start work on a definite section of the map with the idea of finishing that up before starting another. From any given position, all the contours running in the most favorable direction are inked in. They may be drawn continuously or by a succession of strokes, whichever method is found to yield the best results. A series of contours should not be ended on a line, to avoid a possible perceptible break when they are afterward continued. Having drawn all the contours both medium and fine that can be drawn in a favorable direction from one position, the position of the body or map is then shifted and all contours having a favorable direction for the new position are drawn. The position is again shifted as necessary until the work in the given area is completed, when a new area is begun. The necessary gaps are left for the numbering of the contours as hereafter described. To prevent obscuring the road symbols, contours should not be drawn across them.

In drawing contours with the contour pen, it is best to follow each contour continuously until a point is reached where there is a break for numbering the contour, where the contour crosses a road, or where there is a sharp bend in the contour at a stream, in order to avoid the difficulty of making a junction when the drawing of the contour is resumed. There will therefore be no particular choice as to the direction of drawing the contours in many cases, as their sinuosities may lead in all directions before a suitable stopping point is reached. If there is any choice, it will be found preferable to draw from left to right and in a direction away from the body rather than in the opposite directions; the former because it is the usual direction for drawing lines with the ruling pen, the latter because in drawing toward the body the shadow of the pen conceals the line to be followed.

In drawing closed contours with the contour pen, individual skill will determine whether to attempt to close with the contour pen or to leave a small break and fill in with the ordinary pen freehand. Usually where there are a number of closed contours around the summit of a hill or mountain, advantage will be taken of the numbering of the contours to make a break in the continuity of each of them and thus avoid the necessity of closing. In case this is not possible or desirable and a number of closed contours must be drawn, the points of closing in the successive contours should not be close together. It is difficult to make a junction without a perceptible fault, and if several of these minor faults occur close together or approximately in line, the faults will be much more glaring than if distributed.

Practically all the foregoing remarks apply equally well to drawing in color on the map or in black on tracing cloth. The advantages of the ordinary pen are much greater in the latter case. The indifferent visibility through the tracing cloth accentuates the difficulties in the use of the contour pen, particularly as the difficulty of joining to a line once discontinued makes it very undesirable to stop and raise the tracing cloth to make sure in case of any obscurity. The decision in favor of the ordinary pen will be more frequent in tracing than in the original work.

In working on tracing cloth, it will be found desirable to use the thinned black ink for the fine line contours, not only because it is easier to draw smooth lines with the thinned ink, but also because when the accentuated contours stand out clear and white on the

blue-print and the intermediate contours take a blue tinge, it contributes to the clearness of the map. In using thinned ink, however, it is necessary to guard carefully against thinning it too much and against too fine a line, otherwise the light on full exposure will get through so that the intermediate contours will be lost in the blue-print. The use of thinned ink, although a valuable adjunct to the topographical draughtsman's art for tracings, has its dangers which must be carefully guarded against.

No distinction has been made in this discussion in the use of contours on maps of different scales, for the reason that the scale and contour interval are usually so chosen that the texture of the contours as drawn is about the same on the different scales. In fact, there are advocates of a "normal" contour interval, so chosen in relation to the scale that the same slope shall always be represented by the same absolute contour spacing on maps of all scales. But the contour interval must be chosen with respect to the relief of the country to be represented, and hence this system breaks down. However, a correct choice of the contour interval will result in a comparative uniformity of contour texture, and no particular distinction need be made concerning contours on maps of different scales. The only difference of any importance is that the weight of the accentuated contours is greater on larger scale maps.

Numbering the Contours.

Contours are numbered in Gothic italic figures $\frac{2}{30}$ inch in height on six-inch maps, and $\frac{1}{20}$ inch on one-inch and smaller scale maps. (See Fig. 12.)

The contour lines are interrupted where the numbers are drawn, the number being placed on the axis of the contour. The numbers must be placed on the contours in enough places so that the elevation of any contour at any point on the map can be ascertained without difficulty. The numbers must be so placed as to be readable from the bottom or from the right-hand margin of the map, and it is preferable that they should read *up* the slope. Advantage should be taken, wherever practicable, of the flatter slopes facing the south and east to enter the contour numbers. As a general rule, groups of contour numbers should be placed at intervals of not more than eight or ten inches around over the map, so that reference will be easy.

The arrangement of these groups of numbers will require careful study. They should preferably be placed in columns perpendicular to the direction of the contours, or the successive numbers may extend obliquely up a slope if they are aligned. The main consideration is that the group of numbers must satisfy the eye by some regular arrangement.

Where suitable places occur, advantage should be taken to enter the numbers of all of the contours on a slope. If three or four such places are found on a map sheet, the requirements of reference will be satisfied by numbering only the accentuated contours at other places here and there on the sheet.

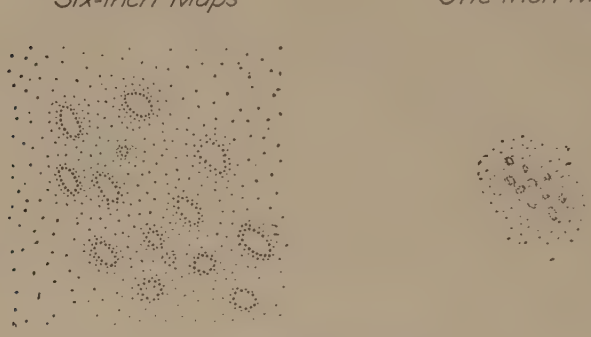

FIG. 36.—Sand dunes.
Conventional color brown. Symbol as shown.

Sand Dunes (Fig. 36).

The tops of the dunes are outlined by a ring of coarser dots, breaking away by wider spacing and diminishing size of dots into the scattered fine dots which constitute the symbol for sand. The tops of the dunes are left blank, or else very few fine dots are used.

The amount of labor required in the execution of this symbol varies inversely as the square of the spacing adopted. As wide a spacing as is consistent with good appearance should therefore be adopted. The texture is coarser as the scale of the map increases.

CHAPTER X

Conventional Signs—Continued

VEGETATION SYMBOLS

General Remarks.

The use of vegetation symbols implies a topographical map, whereas those heretofore discussed are of general use on all classes of maps, engineering and civil as well as topographical.

Vegetation symbols are intended primarily for use on large scale maps, because the selection of a small scale indicates that details of a minor nature are not desired. But a distinction should be made between those symbols which represent vegetation more or less permanent in character, such as woods of all kinds, orchards, and rice, and those of a very temporary nature such as the annual crops like corn, cotton, wheat, etc., which may the next year be replaced by vegetation of a different character. Woods may be cleared and the land taken under cultivation, but in most thickly settled areas the woods are no more likely to change than much of the other data on a map where minor detail is shown. Orchards, although less permanent in character than woods in general, are still sufficiently permanent to be recorded on a detailed map the useful life of which is comparatively short. Rice, although an annual crop, requires careful and expensive preparation for its culture, and ground once prepared for its cultivation is generally thereafter continuously used for that purpose. Grass and meadow lands are less permanent in character, and occupy an intermediate position between the permanent and the purely temporary classes of vegetation.

On large scale topographical maps, the symbols representing vegetation of a permanent character will of course be used. Whether or not those representing purely temporary vegetation are used will be decided in each case by the purpose of the map. In military maps, for example, the purely temporary

vegetation may be left off of the office record map and the tracing. A blue-print, revised from year to year, supplies the data for additions to the tracing at any time that circumstances require an issue of these maps for important use.

On one-inch and smaller scale maps, the use of symbols representing vegetation of permanent character will be determined by the character and occurrence of the vegetation. Only the larger areas of woods and orchards will, as a rule, be shown. Small woods and the usual farm orchards do not offer sufficient space in which to execute a legible symbol, and it is better to leave off the symbol entirely than to convey wrong information concerning the area covered. The condition will be evident by considering the impossibility of representing several different patches of woodland in the square inch which represents one square mile of ground. But the large timbered areas are important, and this information should not be left off the map merely because all of the small patches of woodland cannot be shown. The same remarks apply to orchards. Rice is very generally cultivated in comparatively large areas, and hence its symbol is quite generally applicable to maps of one-inch and larger scales.

In the following pages the various vegetation symbols will be discussed. The details of the execution of the symbols will be shown where necessary on enlarged scale, together with the minor variations of form used to break the monotony of the symbol. Examples of execution appropriate for six-inch and (where applicable) one-inch maps will be given.

The same general form is followed in all the figures showing vegetation symbols. For those symbols applicable only on large scale maps, the figures show at the left the details of the symbol enlarged, and the variations used to avoid monotony; in the right-hand portion of the figure, in the area marked 6″, is shown an example of the execution of the symbol suitable for use on a six-inch map.

In cases where the symbol is applicable to both large and small scale maps, the figure consists of four quadrilaterals, two rectangles forming the upper part and two squares the lower part. In the upper left-hand rectangle are shown the details of the symbol enlarged, and the variations of the symbol used to avoid monotony, in size suitable for use on six-inch maps. In the

upper right-hand rectangle are shown the variations in the form of the symbol, in size suitable for use on one-inch maps. In the lower left-hand square (marked 6″) is shown an example of execution of the symbol suitable for six-inch maps, and in the lower right-hand square (marked 1″) the same for one-inch maps.

The topography of the six-inch example is in each case taken from the lower center of the one-inch example, a leader serving to direct attention to identical features in the two areas. The limits of the six-inch area are indicated in dotted lines on the one-inch area. The parallel execution on the two different scales serves to keep vividly before the mind the distinction between large and small scale maps in the matter of detail shown.

As a general rule, the size and spacing of the symbols increase with the scale of the map, though not in proportion to the scale. The spacing of the symbols should be as wide as is consistent with good appearance. It is to be borne in mind that the number of symbols to be drawn in a given area varies inversely as the *square* of the spacing adopted.

All symbols are shown in conjunction with contours, because such is the normal condition. Where the symbol implies level ground, as marsh and rice, contours are of course not shown.

When drawing in color, the vegetation symbols may be drawn directly over the contours, as the transparency of the green does not interfere materially with the brown lines of the contours. Such practice will generally be necessary where the contours are closely spaced. As a general rule, even in color, the lines of the vegetation symbol should be kept clear of the contour lines wherever possible.

In black on tracing cloth, the vegetation symbols are drawn in very fine lines with thinned ink. This serves to preserve the relative values of the vegetation symbols and contours on the blueprint. In drawing in black, a greater effort should be made to keep the vegetation symbols from encroaching upon the contour lines than is done when drawing in color.

On all field sheets, the vegetation symbols may, and properly should, be omitted and the name lettered instead. If not definitely indicated in boundary by fence or stream symbols, the boundary of the area covered by each particular class of vegetation must be otherwise clearly indicated so that no mistake can be made in the draughting office.

Grassland in General (Fig. 37).

Grass is the least important class of vegetation to which a special symbol is devoted, yet in many portions of the country it covers the principal part of the surface. In such cases, the symbol for grass may be omitted, it being understood that the absence of other symbols represents the usual condition of grassland, or a marginal note to that effect may be made. Thus the map will be relieved of a symbol over the greater part of its

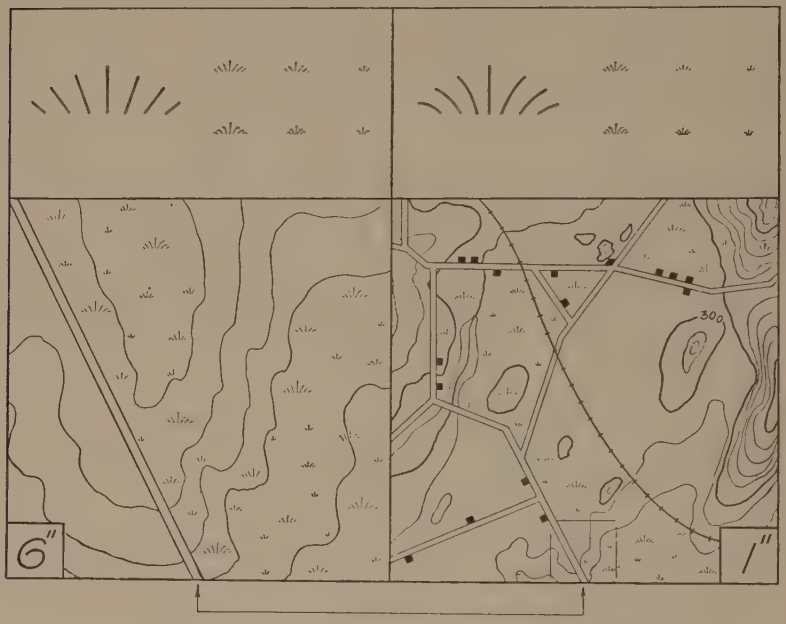

FIG. 37.—Grassland in general.
Conventional color green. Fine lines. (If drawn in black, very fine lines.)

area, with gain in clearness and reduction of draughting cost. The absence of a symbol on the major portion of the surface of a map will serve to accentuate the symbols actually drawn, which is entirely proper because in this case the classes of vegetation represented by symbols are the most important.

But where the greater part of the area of the map is covered by symbols representing other classes of vegetation, it is better practice to draw also the symbol for grass, because the draughting labor will not in this case be so greatly increased, and for

the further reason that the absence of a vegetation symbol would serve to accentuate the areas occupied by a class of vegetation actually the least important.

The details and execution of the grass symbol are shown in Fig. 37. The symbol consists of seven, five, or three strokes, though occasionally two or even one may be used.

The strokes radiate from a point about half the width of the symbol below the center of its base. Instead of all straight strokes, the center stroke may be made straight and the others curving slightly outward from it. The strokes must all terminate accurately on a line parallel to the bottom edge of the map. The lengths of the strokes diminish outward from the center so that the outer strokes are little more than dots. The height of the center stroke diminishes with the number of strokes in the symbol, and the width of the symbol should be approximately three times the height of the center stroke.

On six-inch maps, the center stroke should be $\frac{2}{30}$ inch high in the seven-stroke, $\frac{1}{20}$ inch in the five-stroke, and $\frac{1}{30}$ inch in the three-stroke symbols. On one-inch maps, the corresponding heights are $\frac{1}{20}$, $\frac{1}{30}$, and $\frac{1}{40}$ inch. The reduced size serves to give the desired finer texture to the execution on the smaller scale maps.

Grass being of irregular growth, the symbols should not be arranged in any geometrical pattern, yet the arrangement should have sufficient regularity that the eye will not be attracted by "holes" or "spots" in the area covered by the symbols.

This question of "regular irregularity" will come up in connection with all the symbols for vegetation of irregular growth. The general method now to be described applies to all of them when executed in comparatively level spaces where there are few contours.

It is best to begin by drawing a sufficient number of symbols to outline the area occupied. These should be alternating large and small and should follow the rules for spacing given below. Next a few of the largest size symbols are drawn quite widely spaced if the map area allows it, and arranged irregularly about over the general area to be filled in. Other symbols, still of the largest size, are now added in the intervals between those first drawn, avoiding horizontal, vertical, and oblique alignment, and keeping a minimum distance of three to four times

the horizontal width of the symbol between each one and its neighbors. When the area has been generally filled in by the largest symbols in this way, the general grouping of the symbols should be examined and the next smaller sized symbol inserted in the larger vacant spaces that catch the eye when looking at the area as a whole. Any smaller noticeable vacant spaces are filled in by the use of the smallest symbol. In this process of filling in with the smaller sizes of symbols, it is necessary to guard carefully against establishing too close a grouping. The vacant spaces must be scrutinized carefully and each symbol so placed as to accomplish the maximum in the way of filling the vacancy. A wrong location of one symbol in this process of filling in will require the use of another. When this is added, the density in this spot is increased so as to call for more symbols in other places to secure uniformity, and the symbols and the difficulties multiply.

As skill is gained in the grouping of a minimum number of symbols so as to satisfy the eye, it will be found possible to meet the requirements of uniform distribution by proceeding regularly over the area, executing first three or four large symbols, and then filling in the intervening spaces with the smaller symbols, and continuing in this manner until the entire area is covered.

In applying the symbol to maps on which the contours are more numerous, the distribution of the symbols is governed somewhat by the spacing and arrangement of the contours. The larger symbols are first drawn in the larger open spaces between the contours, preserving the rule of three to four times the horizontal width of the symbol as the minimum distance between symbols. Uniformity of texture is then secured by the addition of the smaller size symbols in the intervening spaces as before. As a general rule, fewer symbols are used as the spacing of the contours becomes closer.

Where the direction of the contours is nearly parallel to the bottom edge of the map, the grass symbols are drawn between the contours, the smaller symbols being used if necessary to secure this result. If the direction of the contours is nearly parallel to the sides of the map, the symbols may, if necessary, be drawn astride the contour lines, but the symbols should be so drawn that the contours pass between the strokes of the symbol. If the contours run in a direction nearly parallel to the

diagonals of the sheet, the symbols should be drawn so that the contours pass between the strokes of the symbol which are nearly parallel to the direction of the contour. If the contours are so closely spaced that none of these artifices are applicable, then fewer symbols are used and effort is made to keep them as well clear of the contours as practicable.

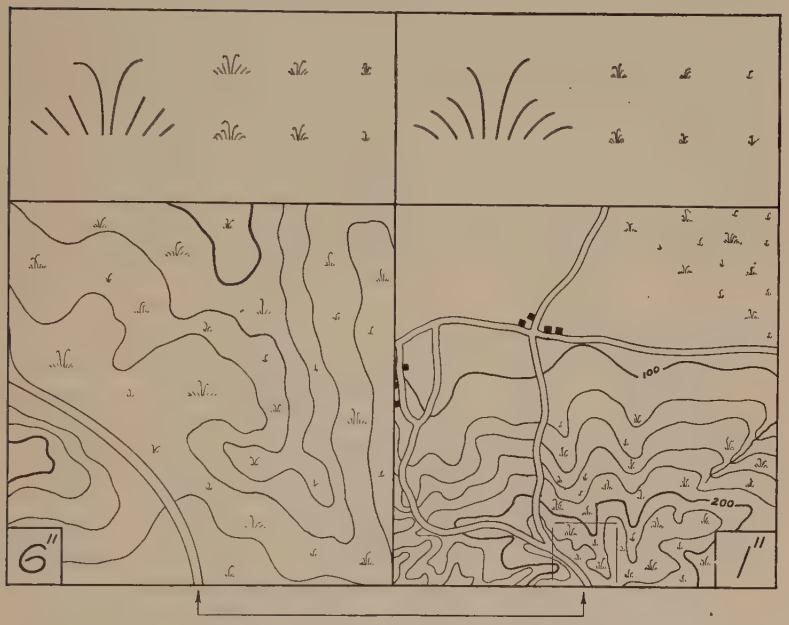

Fig. 38.—Tall tropical grass.
Conventional color green. Fine lines. (If drawn in black, very fine lines.)

Tall Tropical Grass (Fig. 38).

This symbol differs from the regular grass symbol in having two or three tall curved strokes in the center, and a more pronounced curve to all the strokes. Liberty is taken here for the first and only time to vary somewhat from the form given in the standard pamphlet of conventional signs. The symbol there given is merely an enlargement of the regular grass symbol. Symbols representing two different classes of vegetation should differ in other respects than in mere size, for the size should vary with the scale of the map. "Tall tropical grass" may be as much as twelve or fifteen feet high, with woody stalks nearly one-half inch in diameter, absolutely impassable to a

man on foot without cutting. It is so radically different from ordinary grass that it is believed that its symbol should be made to differ more radically.

With the addition of the tall curved strokes, several variations may be made in the individual symbols. The principal ones of these are shown in Fig. 38, together with examples of execution on six-inch and one-inch maps. The width of the symbol is the same as that for ordinary grass. The height of the tallest strokes is about equal to the width of the base of the symbol.

The arrangement of the symbols for uniform texture with irregular distribution is secured by methods similar to those given in the discussion of the grass symbol. On account of the larger size of this symbol, the absolute spacing is somewhat greater than for the regular grass symbol.

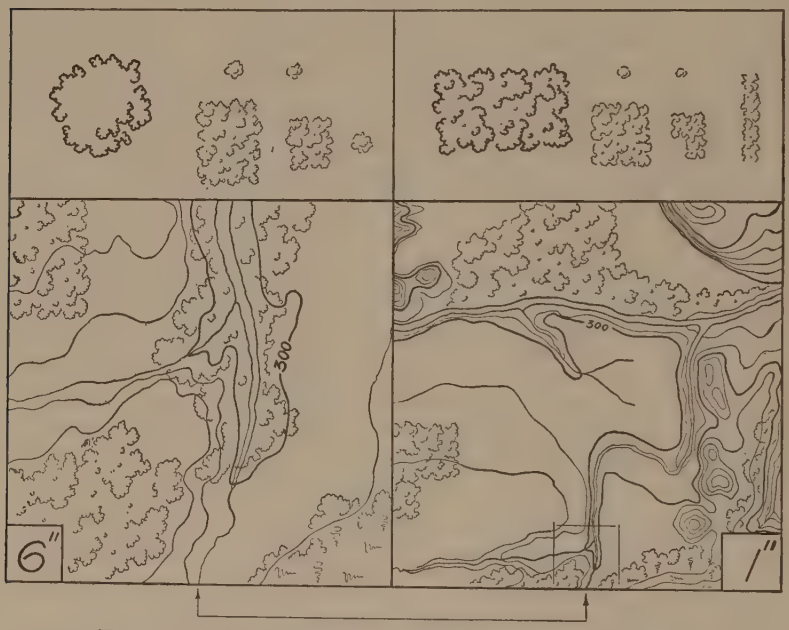

Fig. 39.—Woods of any kind (or broad-leaved trees).
Conventional color green. Fine lines. (If drawn in black, very fine lines.)

Note.—A flat tint or wash of green may be substituted for this symbol on any map drawn in color.

Woods (Fig. 39).

The basis of the general symbol for woods is the individual

tree symbol. This symbol is meant to resemble the projection of a tree upon the ground, with the added condition that the source of illumination is on the 45° line upward and to the left. The foliage on the lower right-hand side of the tree is thus assumed to be in partial shade.

The minimum size in which the individual tree symbol can be legibly rendered is about $\frac{1}{10}$ inch in diameter, corresponding to an actual diameter of 88 feet on a six-inch map, and 528 feet on a one-inch map. From this it is manifest that only the larger wooded areas can be represented on one-inch maps, and that individual trees cannot be represented to scale even on six-inch maps. In fact a single tree, unless it stands at the intersection of two roads and thereby serves to identify the point, or is in a prominent position on a hilltop, does not properly belong on any except a large scale map intended for studies in landscape architecture.

The individual broad-leaved tree symbol is therefore a symbol only, but its form must be studied as the basis of several other symbols. It is generally circular in form, made of three or four disconnected parts each consisting of a series of loops convex outward from the center, as shown in Fig. 39. One or two shade lines are added at the lower right-hand side of the symbol. Although adhering to a generally circular form, the symbols are made in variety, no two alike. Especially to be avoided is a completely closed ring of regular loops. This gives a very unsatisfactory symbol, disagreeable in its monotony.

The symbol for trees in mass is not made up of individual tree symbols irregularly distributed with smaller symbols interspersed between, as is the case with the grass symbol. The outline of the woods is made up of disconnected parts each consisting of a series of loops convex outward from the center of the woods, exactly as if a single tree symbol were expanded in perimeter so as to enclose the whole area. The interior of this area is now filled in by partial symbols so arranged as to suggest in effect the principal shade masses of the wood as viewed from above. Under the same assumption as before concerning the source of illumination, the majority of these partial symbols will be similar to the lower right-hand part of the individual tree symbol. These partial symbols are kept well dispersed so as to reduce the labor of execution and to keep the symbol of the proper density. (See Fig. 39.)

The symbol for broad-leaved trees in mass is a difficult one to execute. Careful study of the symbol and considerable practice are necessary to secure satisfactory rendering.

In military maps, it is important to know whether or not woods are of such dense and tangled growth as to require cutting to permit the passage of troops. If so, the symbol shown in the lower right-hand corner of the six-inch and one-inch areas in Fig. 39 is used to indicate this fact. The execution of this symbol requires no special comment. It is simply a wavy line with waves of diminishing amplitude. Some of the symbols are executed with their length parallel to the bottom of the map, and the remainder perpendicular to it. This symbol should be drawn before the woods symbol in ink. The symbol is applicable generally to all kinds of woods.

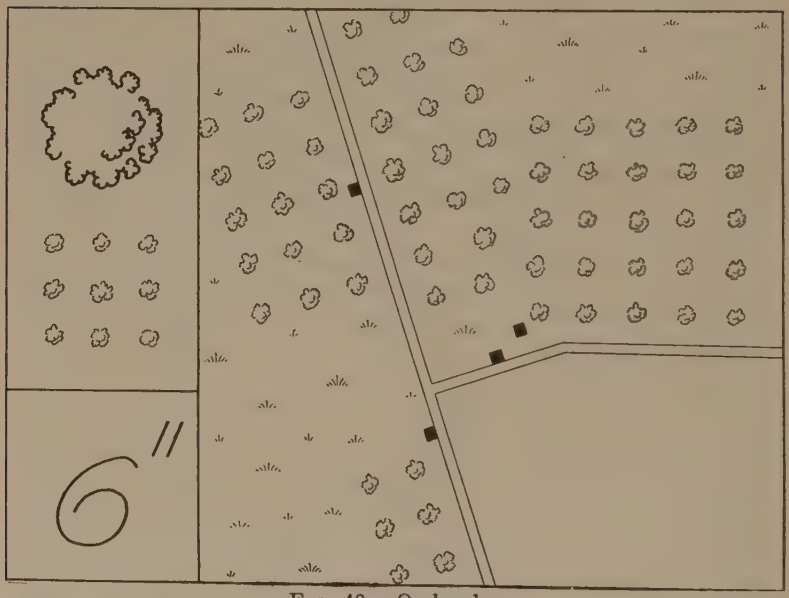

FIG. 40.—Orchards.

Conventional color green. Fine lines. (If drawn in black, very fine lines.)

Orchards (Fig. 40).

The symbol for orchards consists of small individual tree symbols arranged in rows and conforming to the plotted outline of the orchard. The size of the tree symbol used will vary with the area covered by the orchard. For large areas on a six-inch map, each

tree symbol should be about $\frac{1}{10}$ inch in diameter, and the rows should be spaced about $\frac{3}{10}$ inches between centers. For the smaller areas occupied by the ordinary farm orchard, the size of the symbol is reduced to about $\frac{2}{30}$ inch in diameter and the spacing to $\frac{3}{20}$ inch between centers of rows.

On one-inch maps, orchards of twenty to forty acres in extent may be shown by four (2x2), six (2x3), or nine (3x3) tree symbols, each about $\frac{1}{20}$ inch in diameter and spaced about $\frac{1}{10}$ inch apart in rows. In large fruit farms, the size of the symbol would be increased to that of the smaller prescribed for six-inch maps. It is evident that ordinary farm orchards cannot be shown on one-inch maps.

Pencil lines should be drawn on the axes of the rows to give accurate spacing and alignment of the symbols. No other vegetation symbols are shown within the limits of an orchard.

Examples of the execution of orchards are given in Fig. 40.

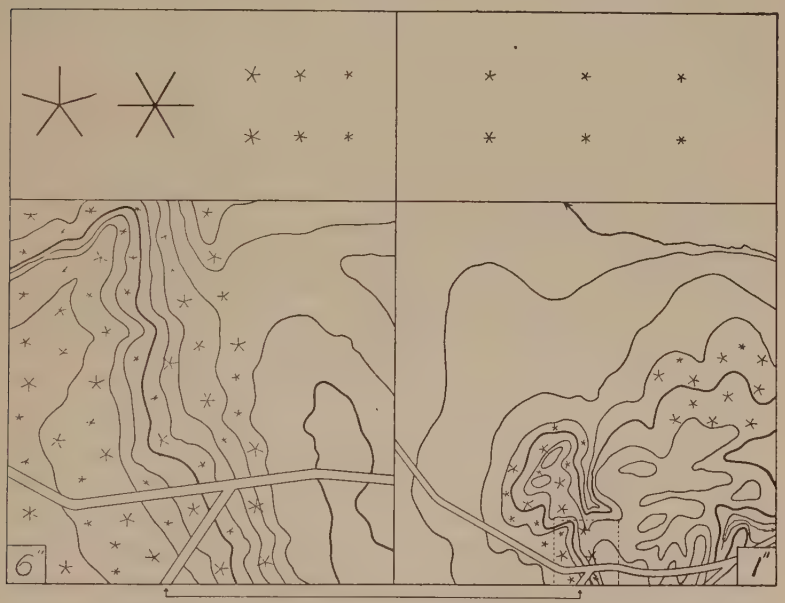

FIG. 41.—Pine (or narrow-leaved trees).
Conventional color green. Fine lines. (If drawn in black, very fine lines.)

NOTE.—A flat tint or wash of green may be substituted for this symbol when drawing in color.

Pine (Narrow-leaved Trees). Fig. 41.

The symbol for an individual pine tree consists of five or six lines radiating from a center and making equal angles with each other. To avoid monotony, the symbols should be varied by changing the azimuth of the symbol as a whole. In the five-stroke symbol, this can be accomplished by making some of the symbols with the upper stroke vertical, some with one stroke horizontal, and some with the lower stroke vertical.

To avoid monotony, the symbol is also varied in size. The maximum size symbol on a six-inch map is that inscribed in a circle $\frac{1}{10}$ inch in diameter, and on one-inch maps in a circle $\frac{2}{30}$ inch in diameter. The smallest symbol used on both scales is one inscribed in a circle about $\frac{1}{20}$ inch in diameter.

The symbol for narrow-leaved trees in mass is composed of the individual tree symbols in varying sizes and azimuths, as have been described. The outline of the area is first marked out by a line of symbols of varying sizes. The interior space is then filled in by first drawing the largest size symbols using a minimum spacing of two to three times the diameter of the symbol, and avoiding any geometrical arrangement. Other smaller symbols are then used to fill in the larger open spaces that attract the eye when looking at the area as a whole, until a satisfactory uniformity of texture is secured. Care must be taken to avoid the use of a multiplicity of symbols.

The use of radiating lines in this symbol makes it necessary to draw some of the strokes in directions most unfavorable for steadiness. The methods of free-hand work described in Chapter V will therefore be specially applicable to this work.

The different strokes of the symbol are drawn toward or away from the center as may be desired. The strokes should meet accurately at the center.

Obstruction to the movement of troops requiring cutting is indicated by the same symbol as described under the general symbol for woods.

Marsh (Figs. 42*A* and 42*B*).

An important exception is made in regard to the general rule of color convention in the case of the marsh symbol. Without other exception the conventional color for all vegetation symbols is green. But the marsh symbol is an important one and

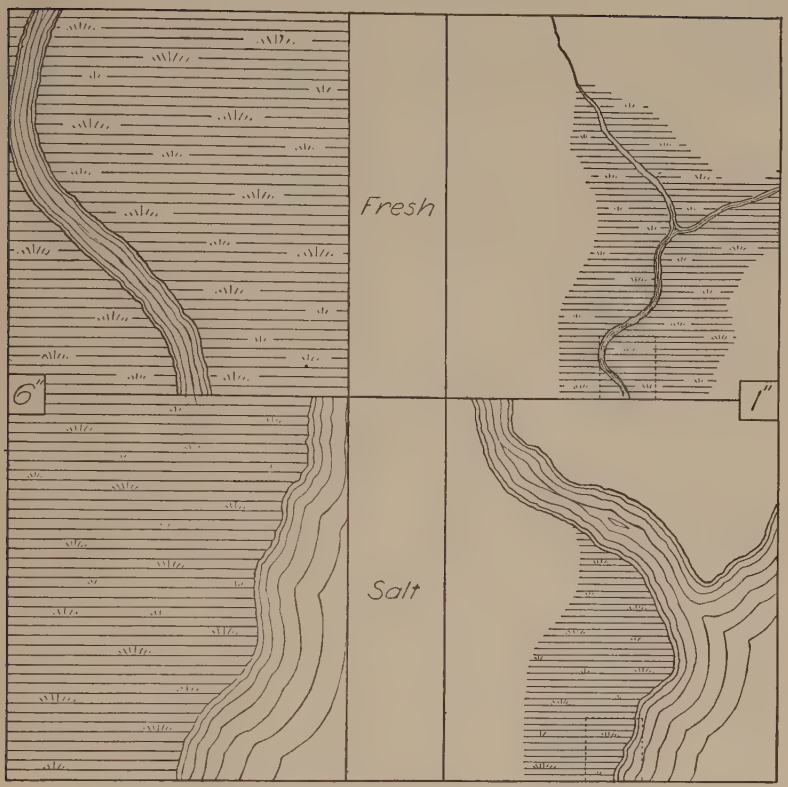

FIG. 42*A*.—Marsh (fresh and salt).

Conventional color—on three-color maps, blue for both section-lining and grass symbol; on four-color maps, blue for the section-lining and green for the grass symbols. Fine lines. (If drawn in black, very fine lines.)

belongs on maps of small scales where no other vegetation symbols are shown, and where consequently only three colors,—black, blue, and brown,—are used. In printed editions of such maps, it would involve an additional plate and an extra printing if the grass symbol were given its regular conventional color. As a matter of economy therefore in printed maps, the grass element of the marsh symbol must be shown in blue. In many ways the printed editions of maps must set the standards for all other maps. In three-color maps, it is desirable to adhere to this exception in the color rules for the sake of uniformity.

The distinction between wooded and other marshes is one which is made only on maps of larger scale, where other vegeta-

tion symbols are shown. The regular color convention is therefore adhered to for the tree symbols used in connection with the marsh symbol. In such maps, the grass symbol should also be drawn in its correct color. The rule may therefore be given that *in three-color maps the grass element of the marsh symbol is drawn in blue; in four-color maps it is drawn in green.*

The fresh marsh symbol consists of horizontal section-lining drawn in fine lines, in which the section-lining is interrupted for the irregular insertion of the grass symbol. This section-lining for all marsh symbols is spaced $\frac{1}{20}$ inch on six-inch maps and $\frac{1}{30}$ inch on one-inch maps. In pencil work, the section-lining is drawn full and the grass symbols are drawn on the axes of the section-lines, irregularly distributed and more widely spaced

FIG. 42*B*.—Marsh (wooded).
Conventional color—blue for section-lining, green for vegetation symbols. Fine lines. (If drawn in black, all lines very fine.)

than in the case of the regular grass symbol. In inking, the section-lining is drawn first, interrupting the lines so as to leave spaces somewhat longer than the width of the grass symbols. The latter are then drawn in, accurately centered in the vacant spaces left for them. (See Fig. 42 *A*.)

In the salt marsh symbol, Fig. 42 *A*, the section-lining is drawn in full lines, and the grass symbols are drawn in,—spaced and arranged as before,—in the intervals between the lines. The size of the grass symbol is reduced for this purpose.

In the wooded marsh, Fig. 42 *B*, the outlines of the wooded areas are marked by a pencil line. The fresh marsh symbol is then drawn in within the balance of the area of the marsh, and the tree symbols (broad-leaved) are drawn in the spaces left for them.

In the symbol for cypress swamp, Fig. 42 *B*, the grass symbol is omitted. The outlines of the areas to be filled by tree symbols are marked in pencil, distributed irregularly and leaving open spaces between for the section-lining. The section-lining is then drawn in, and the narrow-leaved tree symbols with an occasional broad-leaved tree symbol are drawn in the spaces left for this purpose.

The draughtsman should cultivate the ability to do section-lining of regular spacing by eye, as this method contributes greatly to speed in drawing the marsh symbol, particularly in small areas. Until this ability is acquired, the spacing may be marked from the scale for the pencil work, or the section-liner may be used. The latter should be used if available for the larger swamp areas, as the speed and uniformity with which the lines may be drawn compensates in the large areas for the time required in setting the instrument for use.

Palm (Fig. 43).

The symbol for the palm tree consists of three parts: the plume of foliage at the top, comprising normally two curved strokes crossing each other; a single vertical line to represent the stem or body of the tree; and a few strokes resembling the grass symbol, except with vertical instead of radiating lines, at the bottom of the stem.

The variations comprise the addition of an extra stroke to the plume, the curve of the upper part of the stem line to the right or

left of the vertical, variations in the number of strokes at the bottom of the stem, and the occasional but sparing use of a smaller symbol.

The total height of the symbol is about $\frac{2}{10}$ inch on six-inch maps, and about $\frac{4}{30}$ inch on one-inch maps.

The individual symbol is drawn by first making the curved strokes of the plume, then from the intersection of these lines is drawn the stem line, and finally are added the short vertical strokes at the bottom of the stem.

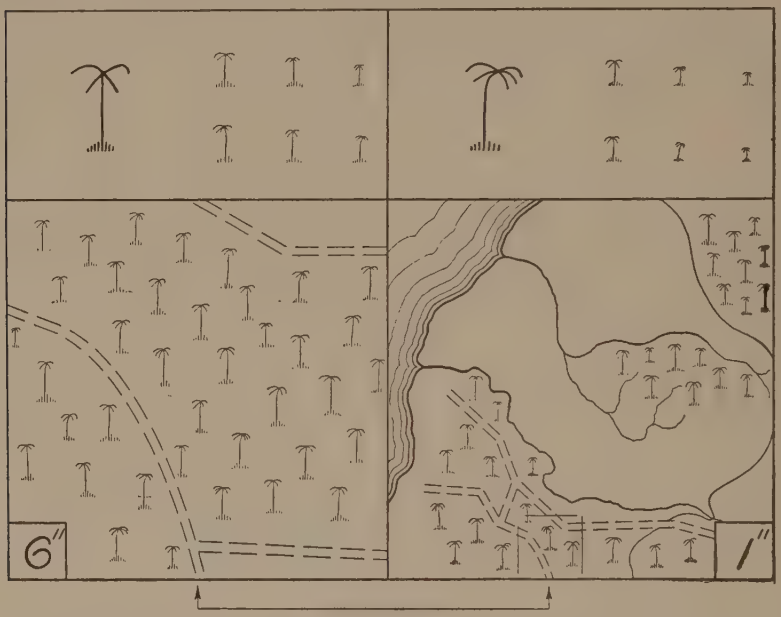

FIG. 43.—Palm.
Conventional color green. Fine lines. (If drawn in black, very fine lines.)

The symbol for palms in mass consists of an irregular grouping of the individual symbols, so arranged and spaced as to present a uniform texture. The variations described are used to break the monotony of the symbol. The normal symbol has a vertical stem, and at least two-thirds of the symbols should be so drawn. Of the remaining third, about equal numbers are drawn curved slightly to the right and to the left. This curvature of the stem must be slight and the bottom part vertical, otherwise an

unsatisfactory general appearance will result. The minimum space between symbols should be about equal to the height of the symbol. An occasional smaller symbol may be used to fill in spaces too large to be left blank but too small to warrant the use of a full-size symbol.

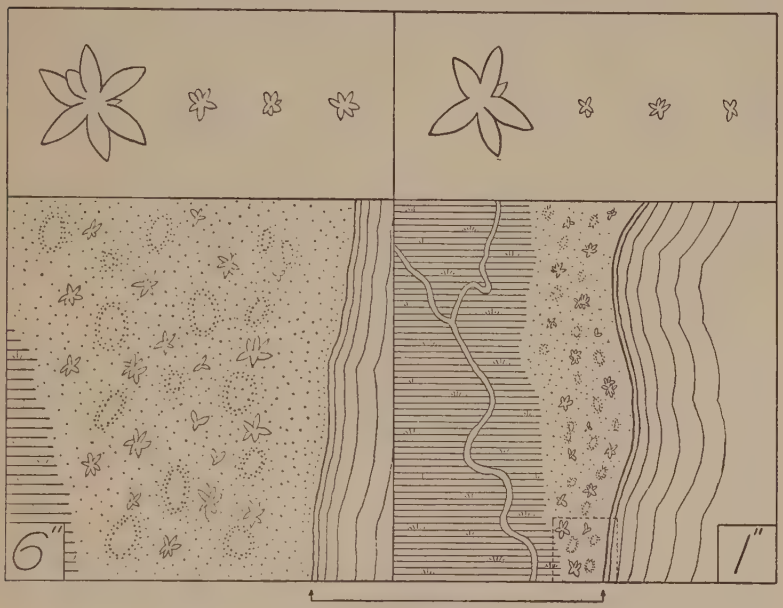

FIG. 44.—Palmetto.

Conventional color green. Fine lines. (If drawn in black, very fine lines.)

Palmetto (Fig. 44).

This symbol is intended to resemble the appearance of the palmetto viewed from above. It consists of from four to seven loops, pointed at the outer end, radiating from a common center. It differs from the symbol for broad-leaved trees in the long and pointed loops. The symbols vary in size, being a maximum of $\frac{3}{20}$ inch across on six-inch maps, and $\frac{1}{10}$ inch on one-inch maps.

The symbol for palmetto in mass comprises individual symbols irregularly arranged, of varying sizes and shapes, with occasional use of partial symbols. The minimum distance between the largest size symbols should be about double the diameter of the symbols. In the intervening vacant spaces smaller symbols and partial symbols are used to secure the desired uniform texture.

Fig. 45.—Mangrove.
Conventional color green. Fine lines. (If drawn in black, very fine lines.)

Mangrove (Fig. 45).

The symbol consists of from two to six or seven leaves on a branching stem. Each leaf is oval and pointed at the outer end.

The symbol for mangrove in mass is executed by first drawing the larger symbols irregularly arranged, and then using smaller symbols in the intervening spaces until the desired texture is obtained. Being a vegetation of swamp growth, the spacing and arrangement of the symbols are independent of contours.

As this symbol is of infrequent use, no further discussion is necessary. The execution is sufficiently indicated in Fig. 45.

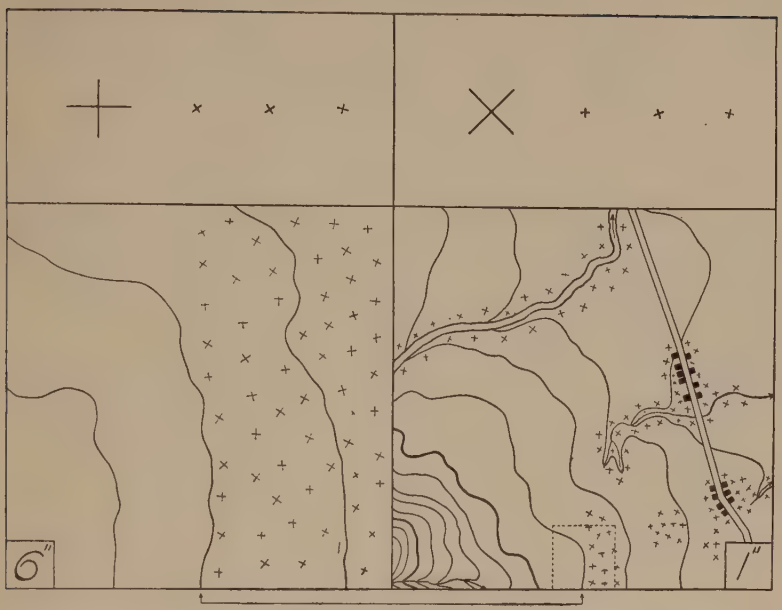

FIG. 46.—Bamboo.
Conventional color green. Fine lines. (If drawn in black, very fine lines.)

Bamboo (Fig 46).

This symbol is merely a small cross, each bar of which should be a maximum of about $\frac{2}{30}$ inch long on six-inch maps, and $\frac{1}{20}$ inch on one-inch maps. The two bars should be mutually perpendicular, and should bisect each other. Variety is secured by drawing the symbol as a whole in various azimuths, and by varying the size of the symbol.

The bamboo symbol is remarkable in being purely artificial. It is one of only two symbols (bamboo and cotton) in which there is no attempt to portray some characteristic feature of the vegetation represented.

In drawing the symbol for bamboo in mass, the area is first outlined by symbols spaced about $\frac{2}{10}$ inch apart. The interior of this area is then filled in by an irregular arrangement of symbols spaced about $\frac{2}{10}$ to $\frac{3}{10}$ inch apart. Smaller symbols are inserted in the larger vacant spaces, as indicated in Fig. 46.

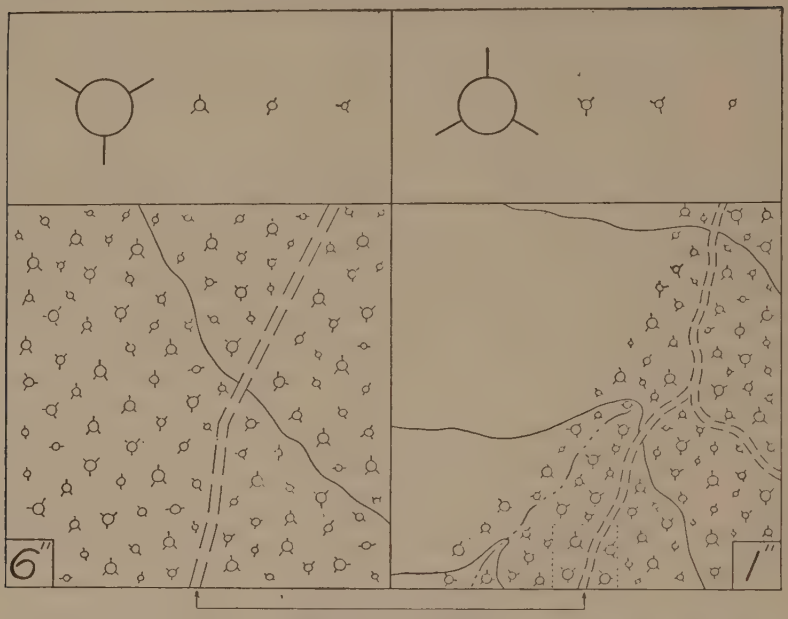

Fig. 47.—Cactus.
Conventional color green. Fine lines. (If drawn in black, very fine lines.)

Cactus (Fig. 47).

The symbol for cactus requires no special comment. It consists of a circle with one, two, or three spines extending outward radially. The circle should vary between $\frac{2}{30}$ and $\frac{1}{30}$ inch in diameter on six-inch maps, and between $\frac{1}{20}$ and $\frac{1}{40}$ inch on one-inch maps. The spines should be about equal to the radius of the circle in length.

The symbol is executed free-hand. The spacing and arrangement of the symbols are sufficiently indicated in Fig. 47.

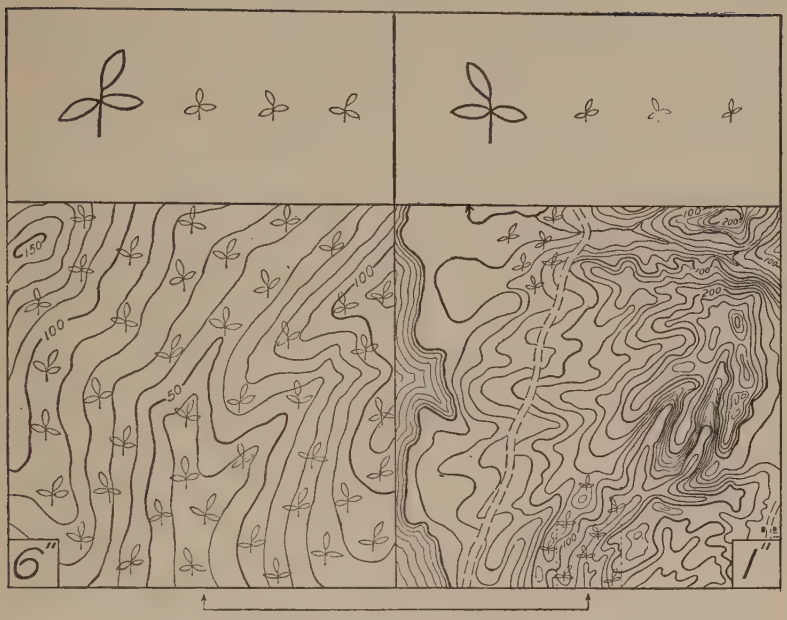

FIG. 48.—Banana.
Conventional color green. Fine lines. (If drawn in black, very fine lines.)

Banana (Fig. 48).

The symbol for banana consists of an upright stem with three pointed leaves, as shown in Fig. 48. The maximum height of the symbol on six-inch maps should be $\frac{3}{20}$ inch, and on one-inch maps $\frac{1}{10}$ inch. The normal symbol has the center leaf vertical and the other two leaves inclining upward from the horizontal symmetrically. Variety is secured by inclining the center leaf to the right or left, and by varying the direction of the side leaves.

The distance between symbols for banana in mass is from two to three times the height of the symbol. Smaller symbols may be used occasionally to secure uniformity of texture with irregular arrangement. The general execution of the symbol is indicated in Fig. 48.

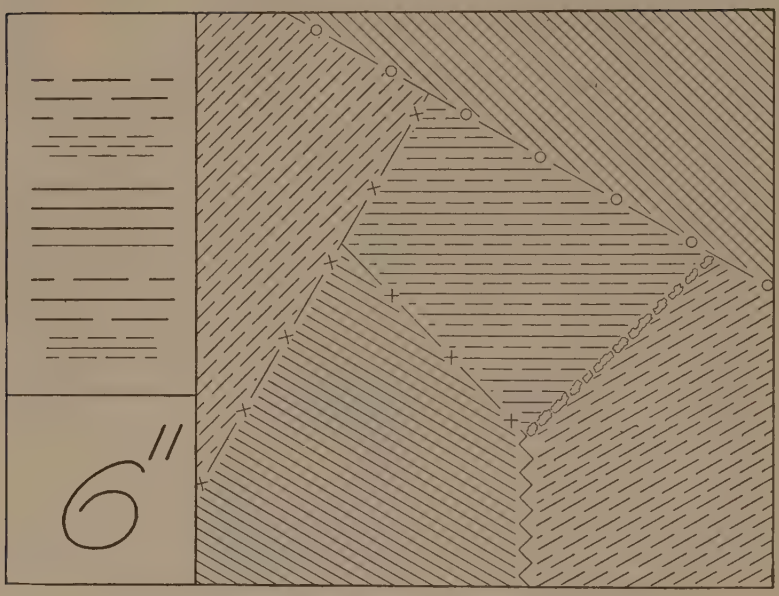

Fig. 49.—Cultivated fields in general (ploughed land).
Conventional color brown. Fine lines. (If drawn in black, very fine lines.)

Cultivated Land (Fig. 49).

The conventional symbol for cultivated land in general consists of section-lining executed mechanically. The section-lining should be spaced $\frac{1}{20}$ inch on six-inch maps, and $\frac{1}{30}$ inch if used on one-inch maps. Variety is secured by the use of full and broken lines in various combinations, as indicated in Fig. 49. If broken lines are used, the dashes of adjacent lines should break joints.

The direction of the section-lining is varied so as to differ in adjacent fields. Usually the 30°–60° and 45° triangles with the T-square will give sufficient variety in direction.

Lines should be drawn in pencil parallel to the fences to limit the section-lining accurately, otherwise a ragged edge of unsatisfactory appearance will result. The margin at fences should be about $\frac{1}{20}$ inch, and should be judged by eye in drawing the pencil limiting lines.

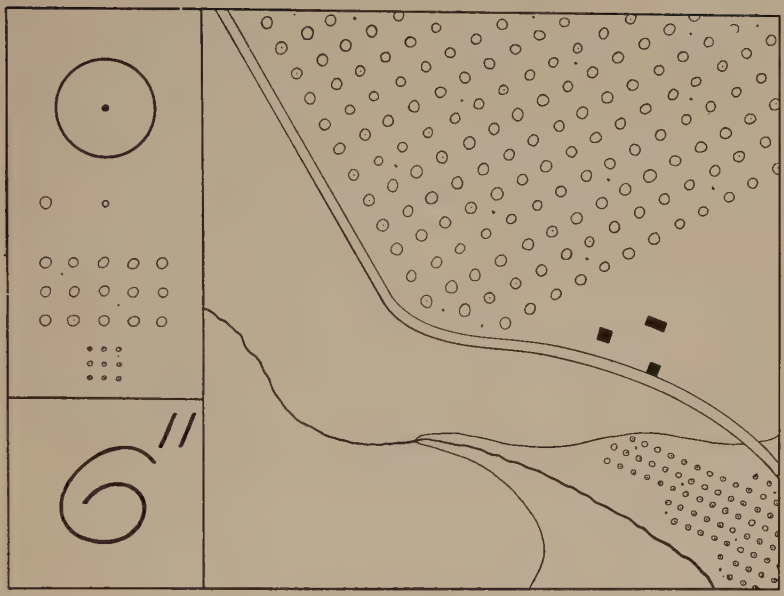

FIG. 50.—Cotton.
Conventional color green. Fine lines. (If drawn in black, very fine lines.)

Cotton (Fig. 50).

It has already been mentioned that the symbol for cotton is a purely arbitrary one. It consists of a circle with a dot in the center. The symbol should be about $\frac{1}{20}$ inch in diameter on six-inch maps. It is not ordinarily used on smaller scales.

Since cotton is a cultivated crop and actually planted in rows, a geometrical arrangement of the symbols should be used. For large areas, the symbol $\frac{1}{20}$ inch in diameter is used with a $\frac{3}{20}$ inch spacing in rows and between rows. For smaller areas, a smaller symbol and closer spacing may be used. Dots are used sparingly in the spaces between rows.

The rows should conform in direction to the boundaries of the fields when these are straight lines. Otherwise the direction is chosen arbitrarily, but for convenience one set of the lines should be parallel to the longer dimension of the area.

Fig. 51.—Rice.

Conventional color—brown broken lines for the division lines between "paddies" or fields, and green for the grass symbols. Fine lines. (If drawn in black, very fine lines.)

Rice (Fig. 51).

The symbol for rice consists of two parts,—the division lines between fields, and the grass symbol. The division lines are purely conventional and make no attempt to represent the plan of the actual embankments or division lines between the fields or "paddies." The symbol indicates nothing more than that rice is cultivated in the given area. The execution of the symbol is therefore governed by such rules as will result in satisfactory representation with a minimum of draughting labor.

The first step in the execution of the rice symbol is to divide up the area into suitable subdivisions of irregular size and shape, bounded by lines generally straight or slightly curved. Here again appears the question of "regular irregularity."

The normal size of the subdivisions on a six-inch map is about ½ inch square, and on a one-inch map about $\frac{3}{10}$ inch square. Considerable study and practice of this symbol will be found

necessary to secure satisfactory execution. The subdivisions are first sketched in pencil in full light lines. The faults to be especially avoided are: arrangement in tiers of rectangular or square areas; acute-angle corners to the subdivisions; too much variation in the size of the areas; too much curvature in the division lines; the use of long, narrow subdivisions; and the use of too many triangular areas.

The scheme of first outlining a subdivision here and there over the area is not applicable in this case, as it is impossible later to connect them up satisfactorily. The area must be covered by the consecutive addition of subdivisions, the majority of which should be four-sided figures, rectangles and parallelograms. The five-sided figure and the triangular areas are used sparingly to break up the tendency to regular arrangement.

Having secured a satisfactory layout of the subdivisions in pencil, the division lines should be inked in broken lines free-hand.

The grass symbols are now drawn in pencil, their bases parallel to the bottom edge of the map. The individual symbols are drawn entirely within the "paddy" subdivisions and never straddle the division lines. Three-, five,- and seven-stroke grass symbols are used, as in the execution of the general symbol for grass. These are arranged so as to give as nearly as possible a uniform texture.

On six-inch maps, three or four grass symbols are normally used in each subdivision, with the occasional use of only two symbols. On one-inch maps, two or three symbols are used in each subdivision, with the occasional use of only one.

In placing the grass symbols, attention must be paid not only to the location of the other symbols in the same subdivision, but also to the location of the symbols in the adjacent subdivisions. This requires that the grass symbols be kept at least half of the normal spacing from the division lines, otherwise they will be too close to the symbols in the adjacent subdivisions.

It is important that the size of the subdivisions and the number of grass symbols per subdivision given be adhered to. The texture given is as coarse as is consistent with good appearance. Finer texture increases greatly the labor required in execution.

FIG. 52.—Sugar cane.
Conventional color green. Fine lines. (If drawn in black, very fine lines.)

Sugar Cane (Fig. 52).

The symbol for sugar cane is used on six-inch maps, and is omitted from maps of smaller scales. The details of the symbol are given in Fig. 52. It consists normally of a vertical stem $\frac{4}{30}$ inch high, and two curved and drooping lines at equal heights representing the blades. Variety is secured by placing these blade strokes at unequal heights. They normally join the stem at about $\frac{2}{3}$ its height from the bottom.

Being a cultivated crop and planted in rows, a geometrical arrangement of the symbols should be used. The symbols are therefore placed in rows $\frac{5}{20}$ inch apart both ways. To execute the symbol, the area is first ruled in pencil in squares $\frac{5}{20}$ inch on a side, the sets of lines perpendicular and parallel respectively to the bottom edge of the map. The stems of the symbol are drawn so as to terminate accurately at the intersections of these lines and thus secure the alignment necessary to good appearance in this symbol. The blade strokes are drawn with the blades at equal heights on about half of the symbols, and with the right and

left blades respectively higher on approximately equal numbers of the remaining half.

The spacing of the lines of symbols may be varied to suit the dimensions of the area to be covered, and both the size and spacing may be reduced in small areas. In ruling the squares in pencil, allowance must be made in the position of the top and bottom lines for the fact that the symbol rests entirely above the top line, and this line must therefore be at a distance from the edge of the area greater than that of the bottom line by the height of the symbol.

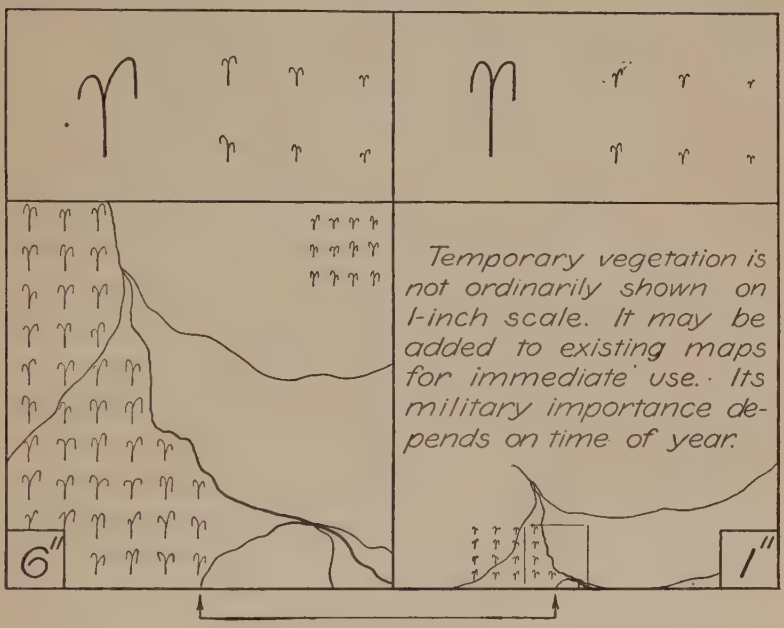
Temporary vegetation is not ordinarily shown on 1-inch scale. It may be added to existing maps for immediate use. Its military importance depends on time of year.
6"
1"

Fig. 53.—Corn.

Conventional color green. Fine lines. (If drawn in black, very fine lines.)

Corn (Fig. 53).

The symbol for corn differs from that for sugar cane only in the omission of that part of the stem which extends above the junction of the blades. The total height of the symbol should be the same as that for sugar cane,—$\frac{4}{30}$ inch.

In all other respects, the remarks in regard to the variation, execution, and arrangement of the symbol for sugar cane apply equally well to the symbol for corn. (See Fig. 53.)

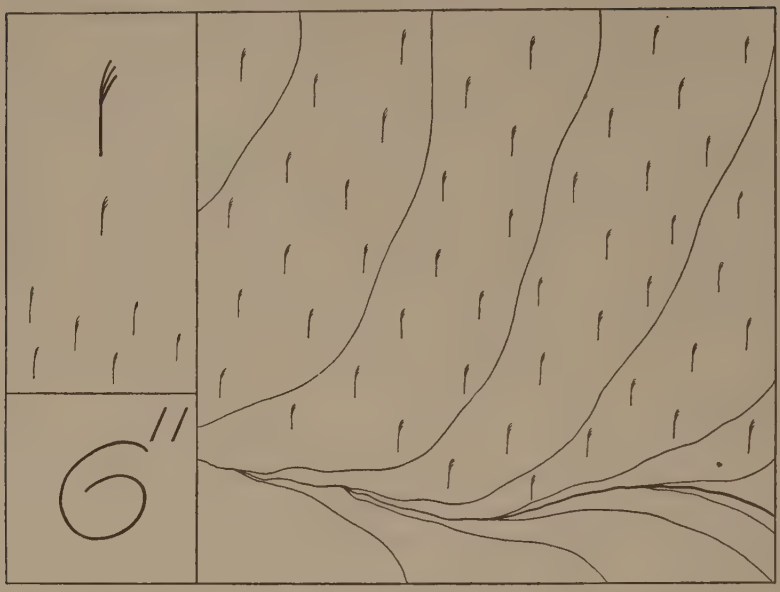

FIG. 54.—Wheat.
Conventional color green. Fine lines. (If drawn in black, very fine lines.)

Wheat (Fig. 54).

It is remarkable that with conventional symbols for so many classes of vegetation, none has ever been adopted to represent any of the cereals except corn. Wheat is the most important of these, and the symbol shown in Fig. 54 is suggested as one appropriate for this purpose. It consists of a stem about $\frac{3}{20}$ inch high, with the addition of two strokes at a very acute angle joining the stem about $\frac{1}{3}$ of its length from the top.

Although wheat is a planted crop and normally drilled in rows, this arrangement is not in evidence generally in the growing crop, so the "regular irregular" arrangement is preferable for this symbol, following the general rule of two to three times the height of the symbol as the distance between symbols. All symbols are of the same size on account of the regularity of the growth of this class of vegetation. An example of the execution is given in Fig. 54.

CHAPTER XI

Conventional Signs—Continued

HYDROGRAPHIC FEATURES

The topographical draughtsman is concerned with the delineation of hydrographic features only in that he may be called upon to draw the features that occur along the shore line.

In lakes and ponds, the broken shore line is used to indicate intermittent bodies of water. In large bodies of water, a full line is used to indicate a surveyed shore line, and a broken line to indicate one not surveyed, and hence known only approximately in its position.

In Figs. 55, 56, 57, and 58 following, the usual rectangles showing details of execution are omitted as unnecessary.

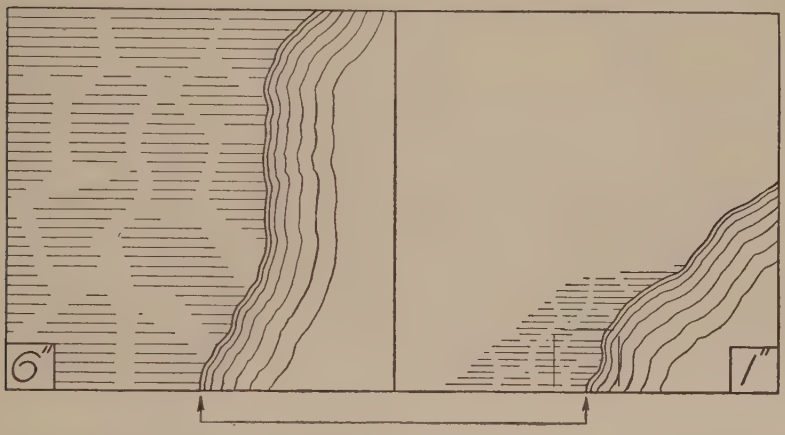

Fig. 55.—Tidal flats of any kind.
Conventional color blue. Fine lines. (If drawn in black, very fine lines.)

Tidal Flats (Fig. 55).

This symbol consists of section-lining with irregular blank spaces indicating the drainage sloughs washed out by the tidal flow. These blank spaces should be outlined in pencil to insure satisfactory appearance in execution. The spacing of the section-lining should be $\frac{1}{20}$ inch on six-inch maps and $\frac{1}{30}$ inch on one-inch maps. Examples of execution on both scales are given in Fig. 55.

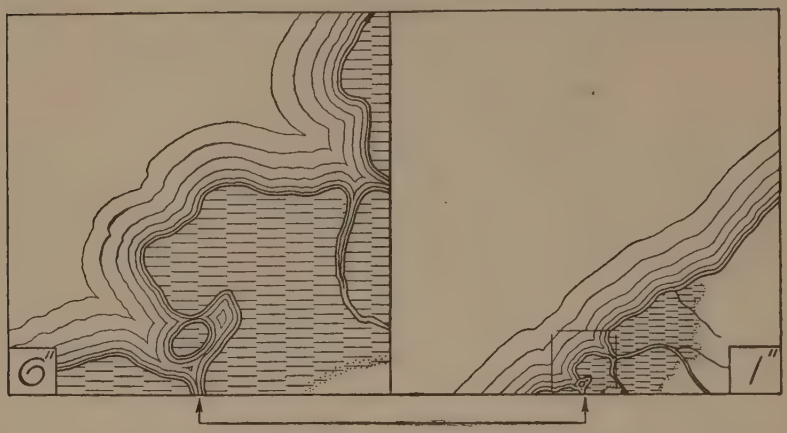

FIG. 56.—Mud flats.
Conventional color blue. Fine lines. (If drawn in black, very fine lines.)

Mud Flats (Fig. 56).

The body of this symbol consists of a form of staggered section-lining, consisting of vertical columns of dashes. In each column, the dashes are opposite the intervals of the adjacent columns.

On six-inch maps, the dashes should be $\frac{3}{20}$ inch in length, and the spacing in the column $\frac{1}{20}$ inch; on one-inch maps, the length is $\frac{3}{40}$ inch and the spacing in column $\frac{1}{30}$ inch.

The execution is mechanical, and the dashes are parallel to the bottom edge of the map. The vertical lines separating the columns of dashes should be ruled in pencil. The spacing should be done by eye, the dashes of alternate columns being drawn entirely across the area at each setting of the T-square.

The shore line is drawn as usual. At the landward edge of the mud flat, dots in blue are interspersed among the dashes to give a satisfactory edge. (See Fig. 56.)

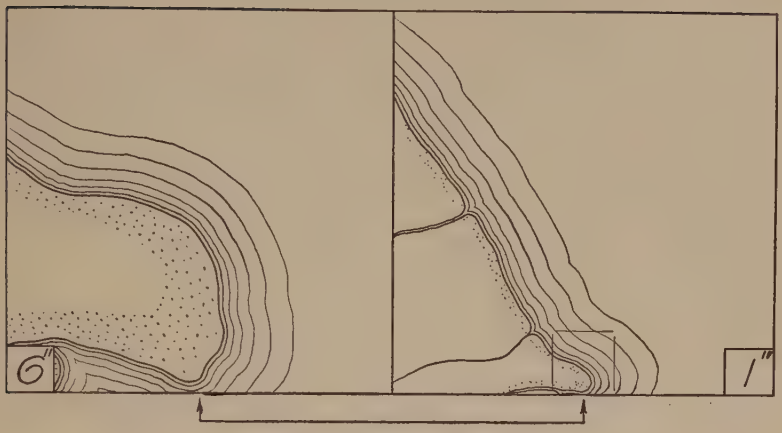

FIG. 57.—Shoreline—sand.

Conventional color—blue for shoreline and waterlining, brown for sand. Symbol as shown.

Shoreline—Sand (Fig. 57).

The water is drawn as heretofore described. (See textual description accompanying Fig. 29 for discussion of waterlining.) The dots representing sand should be kept as widely separated as is consistent with good appearance, in order to economize draughting time. A suitable texture of execution is indicated in Fig. 57.

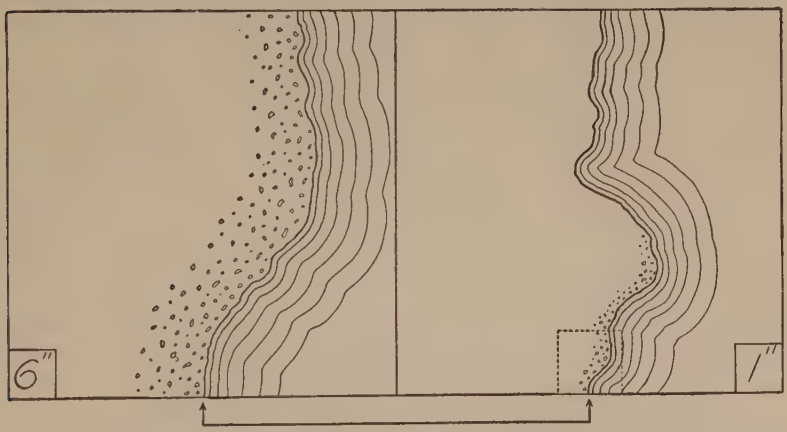

FIG. 58.—Shoreline—gravel and rocks.

Conventional color—blue for the shoreline and waterlining, brown for gravel and rocks. Lines as shown.

Shoreline—Gravel and Rocks (Fig. 58).

This symbol differs from that for sandy shoreline in the sub-

stitution of small circles and irregular figures for the dots of the conventional sign for sand.

The spacing is as wide as is consistent with good appearance. The size of the individual symbols for gravel and rocks should vary with the actual character of the beach. If the gravel is fine and the rocks few and small, a fine texture should be used; if coarse gravel and large rocks, a correspondingly coarser texture should be used to show this fact. An example of the execution is given in Fig. 58.

Where the shoreline becomes rocky and precipitous. the symbol shown in Fig. 34 is applied to the shoreline

SPECIAL MILITARY SYMBOLS

To record the positions, works, and operations of military forces, special military symbols have been adopted. They are shown in Figs. 59, 60, and 61.

The execution of these symbols is mechanical and requires no special comment. On account of the minute detail which these symbols imply, they may be regarded as generally inapplicable to maps of scales smaller than six inches to one mile. To distinguish the opposing forces in military operations, the symbols representing each force may be drawn in a characteristic color.

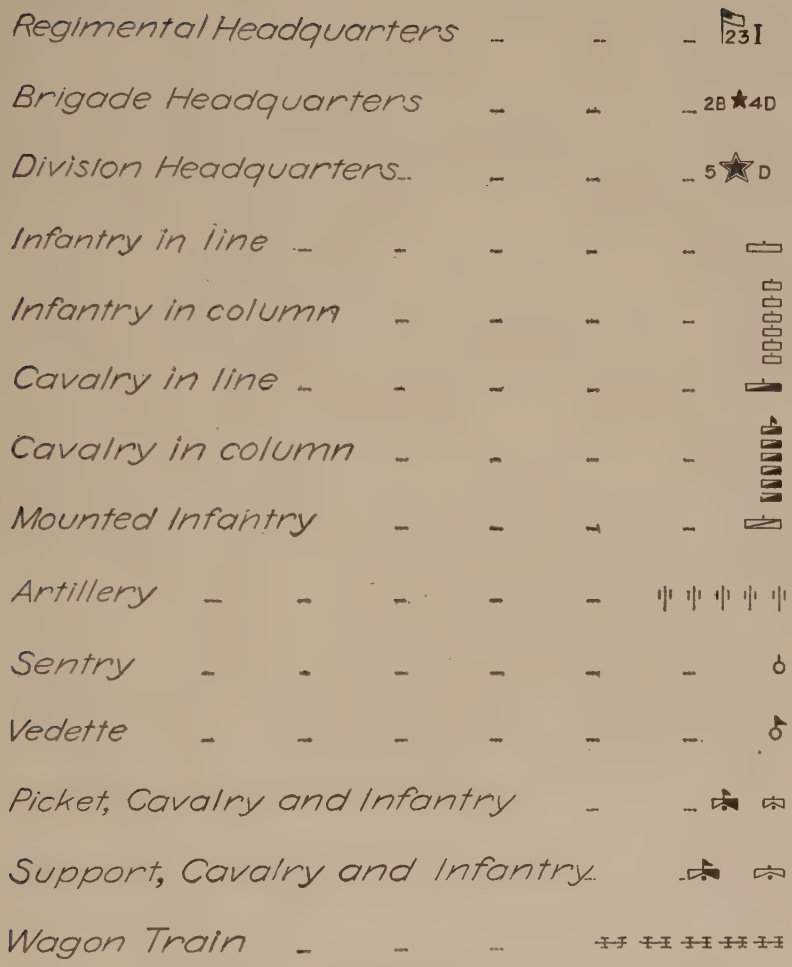

FIG. 59.—Special military symbols.
Conventional color black. Lines as shown.

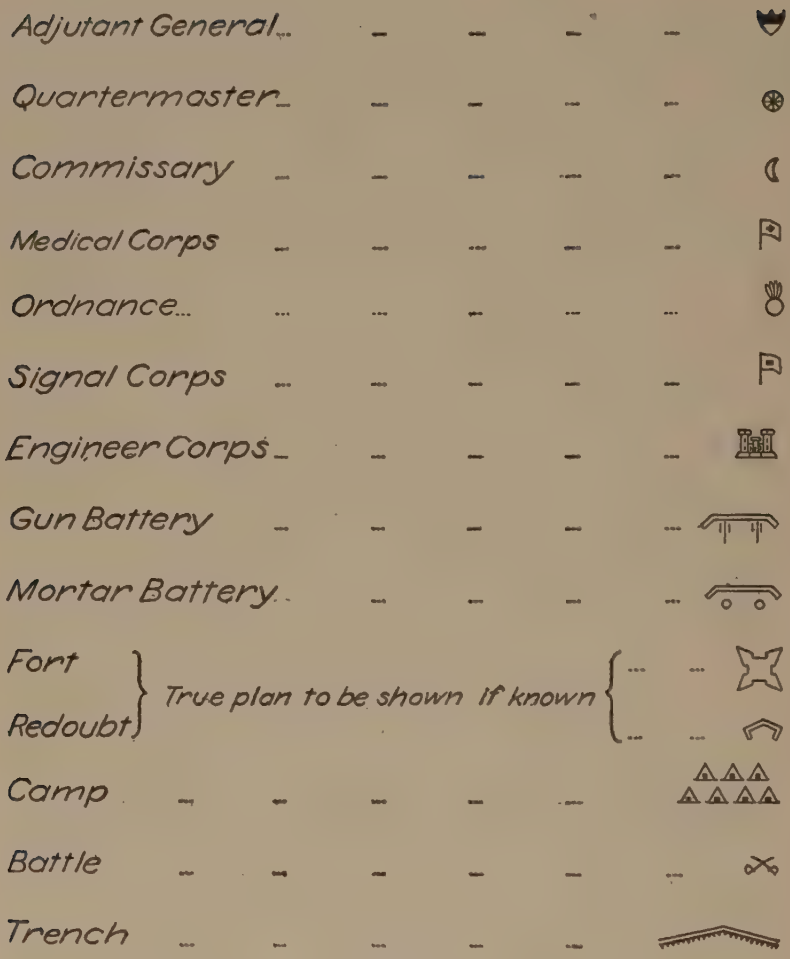

FIG. 60.—Special military symbols.
Conventional color black. Lines as shown.

FIG. 61.—Special military symbols.
Conventional color red. Fine lines.

CHAPTER XII

Map Drawing

Map drawing is the delineation of information concerning the surface of the ground by means of conventional signs and other conventional methods of representation. The character of the information shown will depend upon the purpose of the map.

The simplest form of map is that showing the boundary lines of property, together with the azimuths of the boundary lines and descriptions of reference marks. Even on such a map or plat, the roads, stream lines, and buildings should normally be shown.

The other extreme is the large-scale topographic map, giving full information concerning the form of the surface, the drainage, roads, railroads, buildings, and all other natural and artificial features. Upon such a map it is necessary to superpose one class of information upon another until the record is complete in all its detail, yet this record must be clear and without confusion or unnecessary interference. Topographical drawing in its widest sense is the art of making this clear and complete record of topographical data.

The subjects of map projection, plotting, lettering and the use of conventional signs individually have already been covered. Their combination in map drawing will offer no particular difficulty until the map is completed in pencil, because interference of data can until then be taken care of by erasures easily made. But the completed pencil work must conform in the order of precedence of data to the rules laid down below, otherwise there will be difficulty and confusion in the inking of the map.

In the execution of a map in ink, the topographical draughtsman can have at most but sparing recourse to erasure, and he should plan and execute his work so that no erasures at all will be necessary. This he can accomplish only by executing in ink the various classes of information in the order of their precedence as given below.

Roads and Railroads.

These have the right of way over all other classes of data, and should be inked first. Each is interrupted in its continuity only by the other and by tunnels. At a grade crossing, both symbols are continuous. If the road crosses above railroad grade, the road symbol is continuous with the necessary bridge symbol at the crossing and the railroad symbol is interrupted. If the road crosses below grade, the railroad symbol is continuous and shows the bridge symbol, the road symbol being interrupted. The symbols for telegraph and power lines, fences, and bridges are now added so far as they appear in connection with the roads and railroads.

Cities, Towns, Villages, and Buildings.

These are inked next because of the importance of this class of information, and because there is no option as to the locations. The only exception is in the case of cities and towns covering large areas. In these it may be preferable to leave out the necessary buildings in some part of the area so as to provide room for lettering the name within the limits of the city or town.

Boundaries.

State, county, township, and other boundaries are drawn next. Such fences as are to be shown other than those drawn in connection with the roads and railroads are now added. In this information, there is again no option as to the location, and the symbols must be continuous.

Names.

In the pencil work, the order of execution of the names differs from that in ink, as the location of the names is optional, and that location should be selected which interferes a minimum with the other data to be shown. Therefore in the pencil work the names are first entered roughly as a memorandum and the lettered layout is made only when all other data except the vegetation symbols has been drawn. In the locations of the names as thus selected, the lettering in ink has precedence over the data following, and is therefore inked in at this time.

Contours.

The numbering of the contours should have been studied and entered in pencil so that appropriate breaks in the contours can be left for the numbering. That having been done, the contours are now inked. The accentuated contours are inked first. The use of the contour pen *versus* the ordinary pen is discussed in connection with Fig. 32. Contours should not be drawn across the road symbols, as no additional information is thereby given and the symbol for the road is obscured. This is particularly true in tracings where the contours are drawn in black, and in rugged country where the contours are numerous.

Contour Numbers.

In order that the contour numbers may be accurately on the axis of the contours as drawn, the inking of the contour numbers is not done until after the contours are themselves drawn in ink. This is true more particularly when the contours are to be drawn with the contour pen.

Streams, Lakes, Ponds, etc.

Next in order are drawn the various water features, with their water-lines where required in the proper representation. Care should be exercised in drawing the smaller single-line streams to see that they cross the contours accurately at right angles and at the points representing the lowest elements of the valleys. In the pencil work the reverse rule governs,—to draw the contours to fit the streams accurately; but in inking, it is better to draw the contours first, particularly if they are to be drawn with the contour pen.

Vegetation Symbols.

Last in the order of the inking of the map proper come the conventional signs for vegetation, as this class of data is to be subordinated to all other information. This can be best accomplished by drawing the symbols after all the other information has been entered.

Title.

After the map is otherwise complete, the title is added, following the model given in Fig. 13 or as described under Fig. 14, whichever is applicable to the particular case.

* * *

Fig. 62 shows a map in four colors, meant to illustrate the standard of practice in topographical drawing as set forth in the preceding pages. The topographical ground-work of this map is taken from an actual survey, in order that it may be fairly representative of actual conditions. It has been necessary to add much detail that is imaginary, in order that the illustration may cover as many of the items as possible. A greater variety of detail is shown than would ordinarily be required to be shown in a map of similar area. A reproduction of this map will form a suitable final practice in topographical drawing. It will be better still for the student to execute according to these standards a map resulting from a survey executed by himself.

SPECIAL SURVEY

A..... B..... IN CHARGE

ROUND ISLAND

WESTON SHEET

65°18' 17' (Luke) 16' 65°15' 41°17'

(Talbot)

(Logan) 8'

16'

(Easton)

C L A R K

L E W I S

RESERVOIR

WATER WORKS

PIPE LINE

Marion Jc.

RED RIVER

MARION BRANCH

F. M. AND H. R. R.

BLACK RIVER

Weston

Indian Creek

(Lyman)

65°18' 17' (Sutton) 16' 65°15' 41°15'

C..... D..... Chief Topographer.
Triangulation by E..... F.....
Topography by G..... H....., and L..... M.....
Surveyed in 19.....

Magnetic 15° True

Scale 1/10560

0 1/8 1/4 1/2 3/4 1 Mile.

Contour interval 10 feet.

Datum mean sea level.

PLATE A.

To Illustrate Topographical Drawing.
April, 1917.

H M

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